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A GUIDE

TO THE

MICROSCOPICAL EXAMINATION

OF

DRINKING WATER

WITH

An Appendix

ON THE

MICROSCOPICAL EXAMINATION OF AIR

[illegible]
14-2

TO

REAR-ADMIRAL THOMAS BRANDRETH,

ONE OF THE

LORDS COMMISSIONERS OF THE ADMIRALTY

AND

CONTROLLER OF THE NAVY,

WHO HAS ALWAYS ESPOUSED THE PRINCIPLES OF HYGIENE

AS APPLIED TO SHIPS,

THE SECOND EDITION OF THIS WORK

Is Dedicated

WITH FEELINGS OF RESPECT AND ESTEEM,

BY ONE WHO HAS HAD THE

PLEASURE OF SERVING UNDER HIS COMMAND,

THE AUTHOR.

A GUIDE

TO THE

MICROSCOPICAL EXAMINATION

OF

DRINKING WATER

With an Appendix

ON THE

MICROSCOPICAL EXAMINATION OF AIR

BY

John Denis

J. D. MACDONALD, M.D., R.N., F.R.S.

INSPECTOR-GENERAL OF HOSPITALS AND FLEETS
EX-PROFESSOR OF NAVAL HYGIENE, ARMY MEDICAL SCHOOL

WITH TWENTY-FIVE LITHOGRAPHIC PLATES

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PREFACE

TO

THE SECOND EDITION.

THE author of this work cannot say with many, that the demand for the first edition has been so great as to call speedily for a second. It has, notwithstanding, enjoyed a steady sale; and if slow it is only what might be expected, when the special nature of the subject is taken into account with the little progress science had made in relation to it when the book was first published.

The practical utility of the method and arrangement employed in this guide has been tested by its adoption in the Army Medical School for several years, and it has been found that, by its aid, even persons little acquainted with Micro-zoology and Phytology have very readily arrived at the nature and name of objects they had never seen before.

It is hoped, however, that the identification of forms will be rendered still more easy by the changes that have been made in the general classification, one of the boldest of which is the removal of the whole of the Flagellata of authors from the Protozoa to the Protophyta. It is full time that this change should be made. Indeed, all modern research and experience would seem to show the propriety of it. In accordance with the views here expressed, the consecutive order of the figures has been somewhat altered, while some have been newly drawn to facilitate reference, and others added to render the work more complete, though, of course, it cannot still profess to be exhaustive.

PREFACE

TO

THE FIRST EDITION.

Officers of Health, as well as Naval and Military Medical Officers, have often to determine the nature of the suspended matters in water used for drinking. In an Hygienic point of view, the import of these suspended matters must vary with their properties, whether mechanical, chemical, or vital.

Mineral particles may affect health, on account of their mechanical action, as, for example, when mineral silt of clay, or fine sand causes diarrhœa. Dead animal and vegetable substances may have more important effects, as, when suspended fæcal matter produces irritation of the whole alimentary tract. On the other hand, living things, such as the ova of Entozoa, the nematoid worms, and small leeches, may give rise at once to certain grave disorders, or Algæ may act on sulphates, and disengage sulphuretted hydrogen. There are, however, numerous living creatures, both animal and vegetable, found in drinking water, to which no special effect on health can be at present assigned; they may be important only as showing the presence of organic impurities, which serve as their pabulum, or as indicating putrefaction. Farther observation may, nevertheless, prove them to be of deeper sanitary significance, and even now, though there is no good evidence of their hurtful action, no one would hesitate to condemn a water containing Bacteria or fungi, or swarming with the lower forms of life. At any rate, whatever may be the conclusions hereafter arrived at, as to the sanitary import of the innumerable suspended matters, it cannot be doubted that Medical Officers of Health should be able to state what they are. This must be done chiefly by the microscope; but, as it is often difficult for those who are unacquainted with Natural History, even with a voluminous work of reference in their hands, to determine the nature of the various objects that may present themselves, the design of the following synopsis is to furnish a number of figures of those objects, with such a commentary as may enable them to be identified. No attempt has been made to link particular forms with special effects; it is doubtful, indeed, if this be possible at present, beyond a limited extent, being rather a point for the inquiry of future times, which this little work can merely purport to aid.

The Tables and figures may also prove useful to young naturalists, who are beginning to investigate the world of waters, that wonderful world, in a single drop of which we may behold varieties of form, almost as numerous as those upon the surface of the great globe itself. Many books have been published with a similar object in view; but one more may find a place, to facilitate the study of a very interesting department of Natural Science.

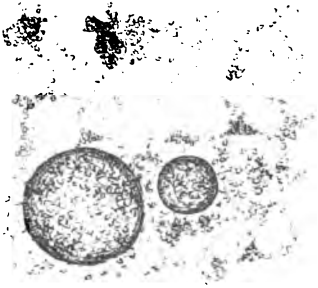
In reference to the Plates, by way of apology, it may be mentioned that, with the view of lessening the expense of publication, the figures have been drawn with pen and ink, but, though they cannot pretend to the fineness and delicacy of steel engravings, some artistic effect has been preserved, and it is hoped that they will answer, equally well, the purpose for which they are intended.

To Professor Parkes, F.R.S., the thanks of the author are especially due, for his valuable advice and guidance, in rendering the treatment of the subject as practical as possible.

WOOLSTON, SOUTHAMPTON,
October 1, 1875.

MINERAL MATTER.

1



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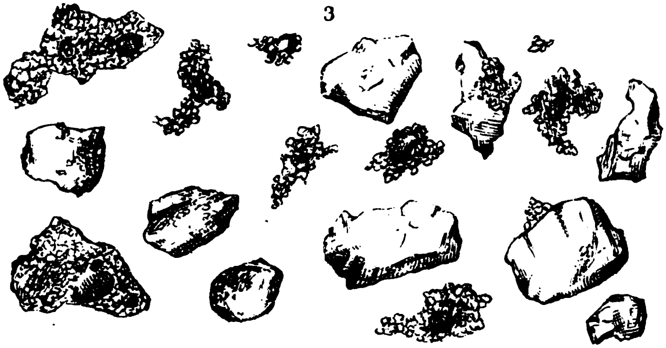

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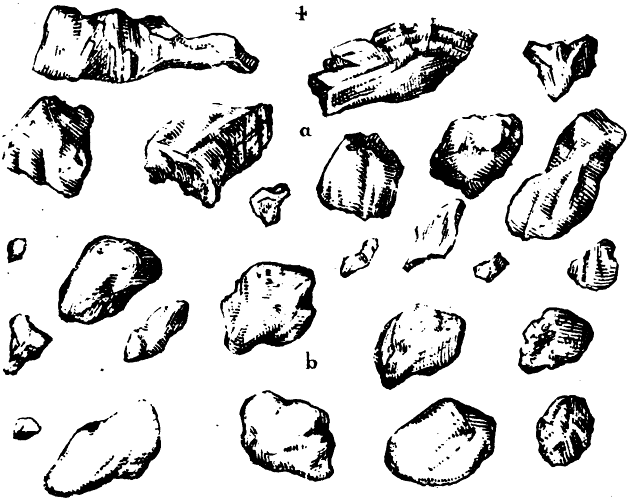

PLATE I.

Mineral Matter.

1. Carbonate of lime, finely divided, with vesicles of atmospheric air, between the glass slip and cover; the vesicles invested with minute particles.

2. Also carbonate of lime, but with the evolution of carbonic acid gas by the addition of an acid; the vesicles are clear and beautiful.

3. Fine green mineral particles, cohering as a microscopic breccia, or conglomerate, are here and there mingled with larger and probably more recent sandy granules, preserving their angularity and roughness from fracture; taken from the débris of a well-sinking, at the Royal Victoria Hospital, Netley.

4. Silicious or flinty granules taken from road-side streamlets, (*a*) more recent, and (*b*) of earlier date, having been rounded off and smoothed by rolling and attrition, like microscopic boulders.

Pl. II

VEGETABLE PRODUCTS.

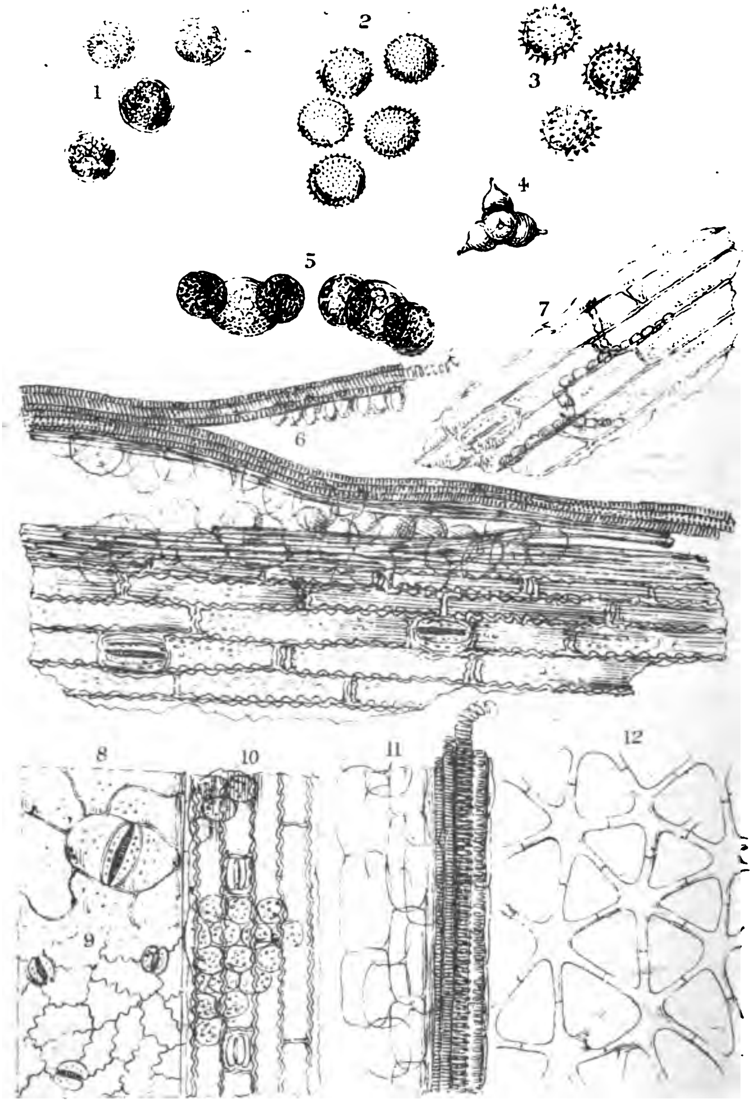

PLATE II.

Vegetable Products.

1. Pollen of Grass.

2. „ of Water-lily.

3. „ of Water-plantain.

4. „ of Rush.

5. „ of Pine.

6. Epidermis, parenchyma, and fibro-vascular tissue of straw.

7. Cuticle of Grass,* with the mycelium of Oidium monilioides.

8. Epidermis or cuticle of Water-plantain.

9. Ditto of the lesser Duck-weed.

10. Cuticle of Carex, with stomata, and some of the round subjacent parenchyma cells seen through it.

11. Section of the stem of Carex, showing the large pith or medullary cells, and a bundle of pitted tissue and spiral vessels.

12. Stellate tissue of the pith of the Rush.

---

* The epidermis and other tissues of grasses, as of hay and straw, derived from stable manure which is being constantly dried and powdered on every road, and widely dispersed by the wind, are very frequently present in water to which they may find access.

Pl. III

VEGETABLE PRODUCTS.

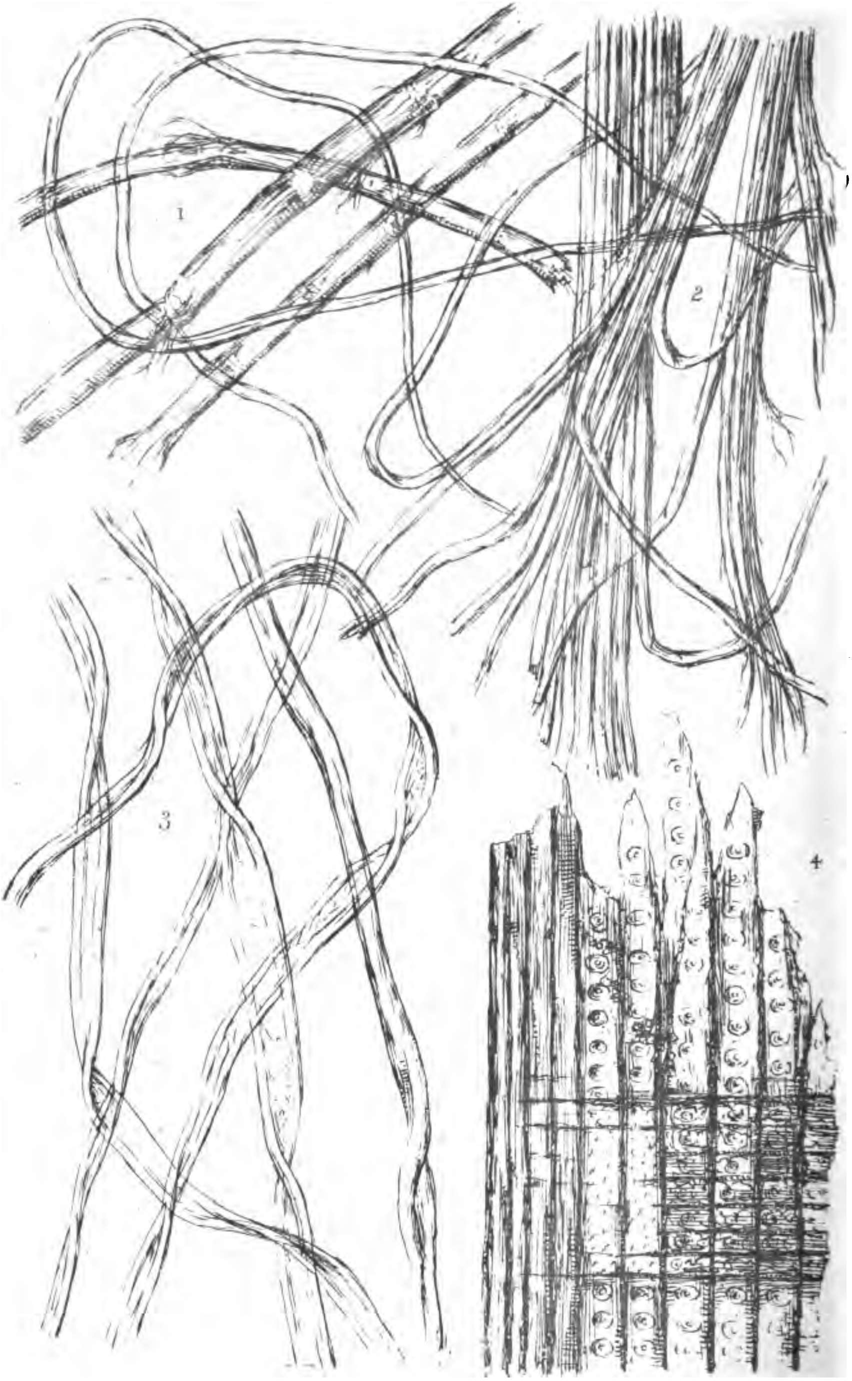

PLATE III.

Vegetable Products indicative of Contamination with House Refuse.

1. Linen fibre.

2. Hemp.

3. Cotton.

4. Chip of deal or pine, with the so-called discoidal tissue, and the silver grain of carpenters passing at right angles to the woody fibres.

Pl. IV.

ANIMAL PRODUCTS.

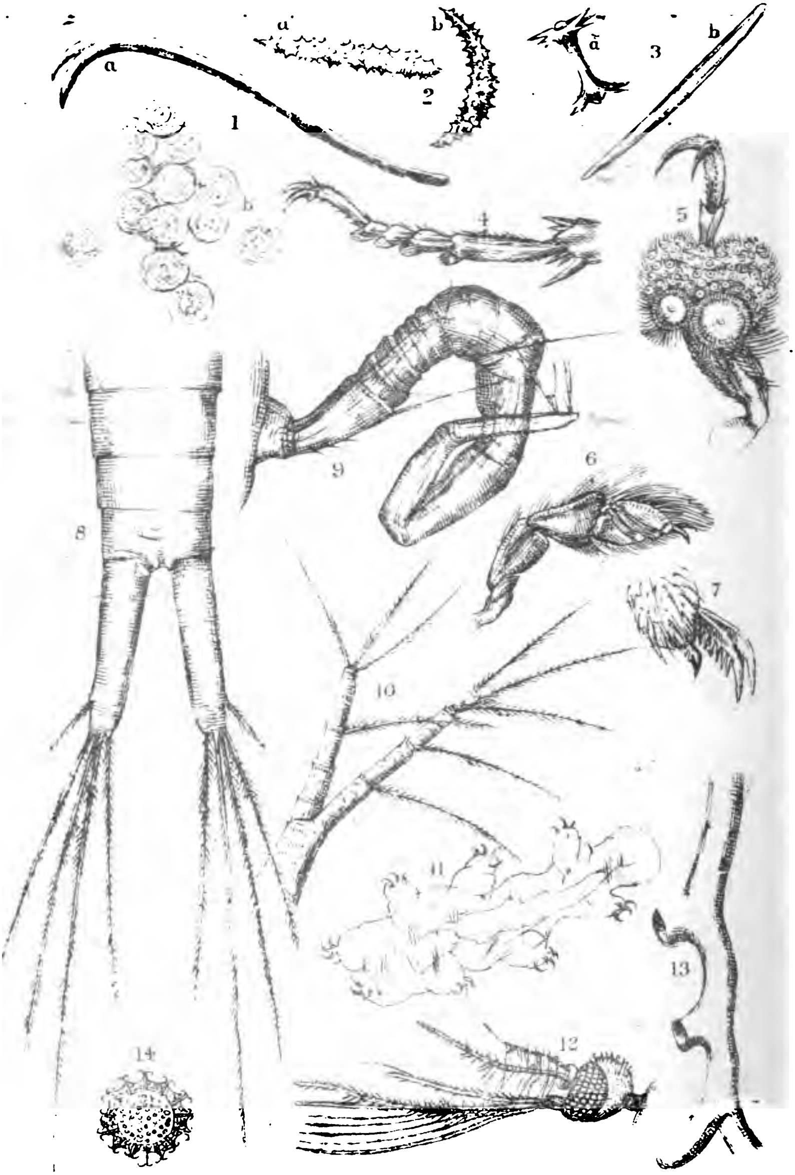

PLATE IV.

Animal Products.

1. (*a*) Ventral hooklet of Nais (a fresh-water annelid); (*b*) liberated ova of the same, often visible when the body of the parent has broken down so as to be indistinguishable.

2. Spiny spicula of Spongilla lacustris, (*a*) straight; (*b*) curved.

3. Spicula of Spongilla fluviatilis, (*a*) birotulate;* (*b*) simple.

4. Part of the leg of a Cockroach.

5. Fore leg of Male Dytiscus.

6. Hind leg of Gyrinus natator.

7. Foot of a Spider.

8. Tail of Cyclops quadricornis (male).

9. Right superior antenna of the same.

10. Inferior antenna of Daphnia pulex.

11. Cast skin of Macrobiotus (Tardigrada).

12. Head and trophi of Gnat (Culex).

13. Portion of the Polypidum of Plumatella (Polyzoa).

14. Egg of Cristatella Mucedo.

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* The corresponding spicules of the Bombay Tank Sponge, Spongilla Meyeni, form very good objects for the microscope.

Pl.V

ANIMAL PRODUCTS.

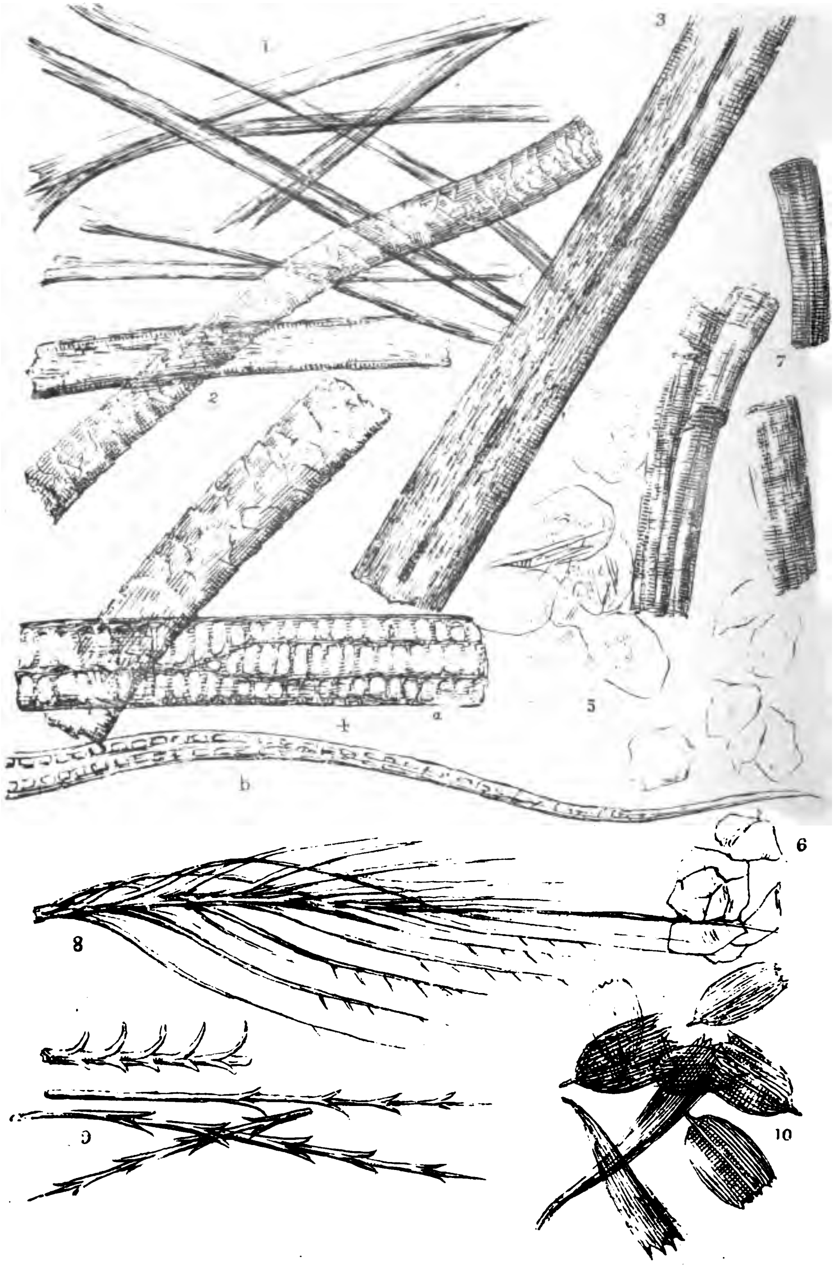


PLATE V.

Animal Products foreign to the Fresh Water.

1. Fibres of silk. 2. Woollen fibre. 3. Human hair.

4. Rabbit's hair, (*a*) the shaft; (*b*) the apex.

5. Nucleated scale-like epithelium from the mouth, &c.

6. Cuticular epithelium, angular and irregular, without apparent nuclei.

7. Striped muscular fibre.

8. Tip of a feather.

9. Barblets of ditto, more highly magnified.

10. Scales of Insects. Besides the Lepidoptera—namely, the Moths and Butterflies, numerous other insects are furnished with scales. Thus they form a velvety coat on the Anthracidæ and Bombylidæ, but are more distinctly scaly on the bodies of many of the Curculionidæ, Melolonthidæ, Clavicornes, Lepismidæ, Poduridæ, and on the wings of the Culicidæ (Siebold).

Pl. VI

BACTERIA.

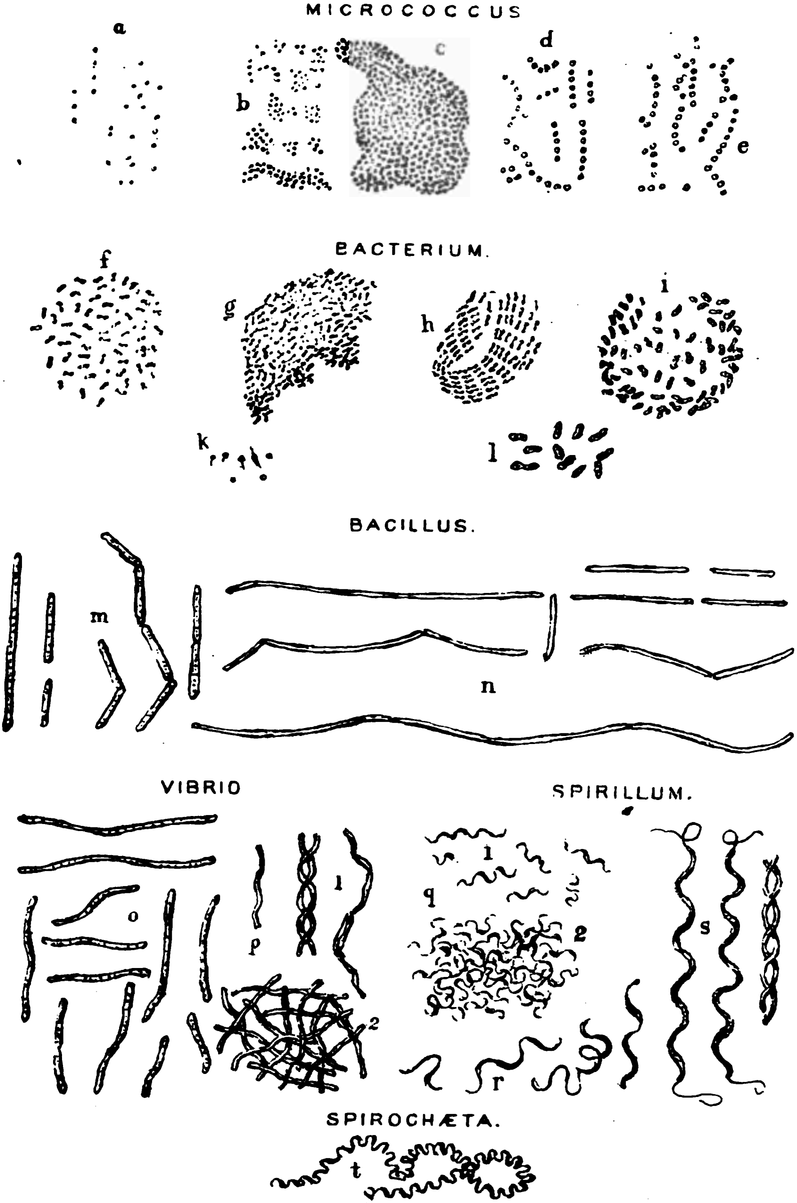


PLATE VI.

Bacteria.

Micrococcus.

a. M. prodigiosus. *b.* M. vaccinæ. *c.* M. crepusculum. *d.* M. ureæ. *e.* An allied species.

Bacterium.

f. B. termo, free. *g.* Ditto in the zooglœa form. *h.* Ditto in linear series.

l. B. lineola, free. *i.* Ditto in the zooglœa form. *k.* Bacteria with highly refracting point.

Bacillus.

m. B. ulna. *n.* B. subtilis.

Vibrio.

o. V. rugula. *p.* V. serpens; 1. free, or in twin spirals, 2. felted together.

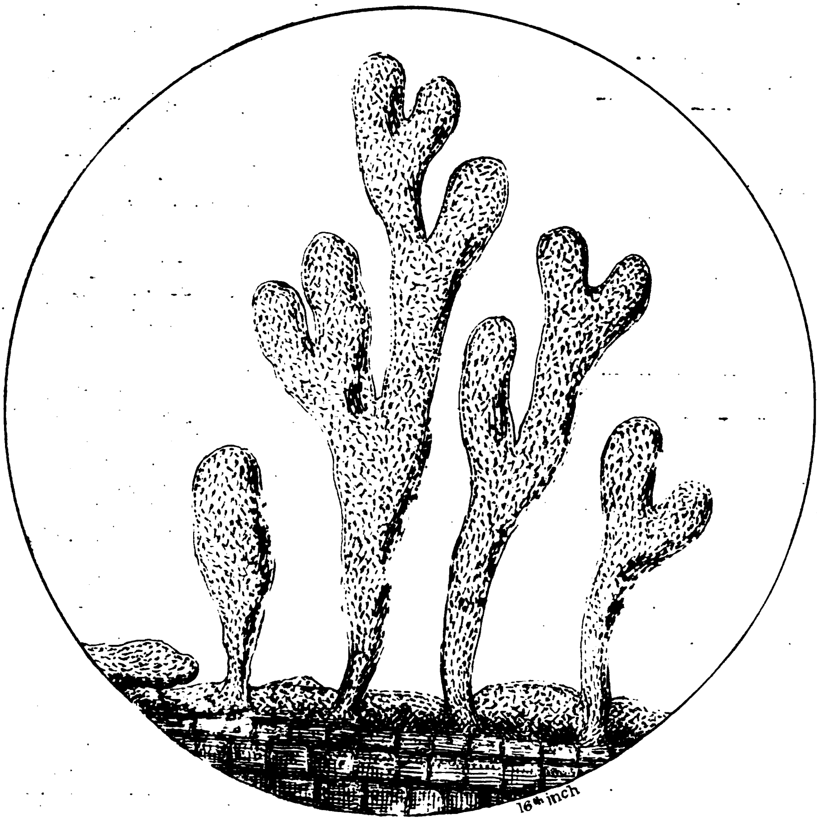
Spirillum.

q. S. tenue; 1. free, 2. felted together. *r.* S. undula. *s.* S. volutans.

Spirochæta.

t. S. plicatilis.

FRONDS WITH BACTERIA.



Minute Bacteroids in clavate simple or branched fronds on a spray of pond weed.

PLATE VII.

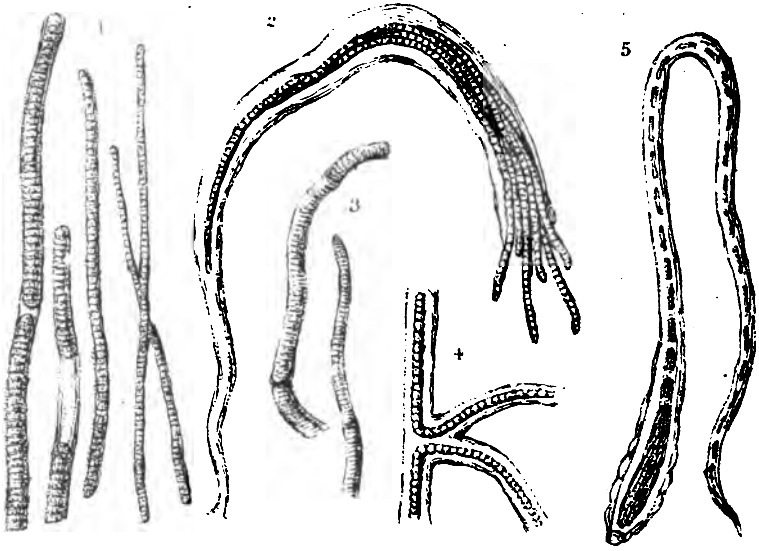
Fronds with Bacteria.

This Plate represents exceedingly minute gelatinous fronds, with embedded bacteroids growing upon a decaying portion of pond weed (Potamogeton). An encrusting layer is seen at the base from which the little fronds spring.

The great number and extreme minuteness of the molecular forms of vegetable life must still claim the attention of Hygieists, from their possible connexion with certain subtle types of disease, until our knowledge has made sufficient progress, either to accept, or reject them as efficient causes.

Pl. VIII.

OSCILLATORIACEÆ.



NOSTOCHACEÆ.

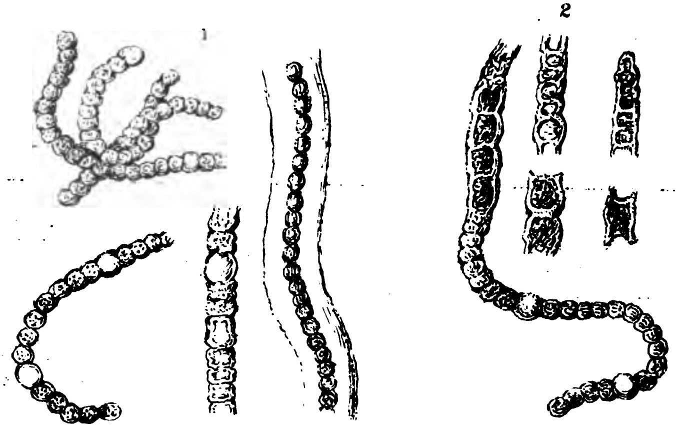


PLATE VIII.

Oscillatoriaceæ.

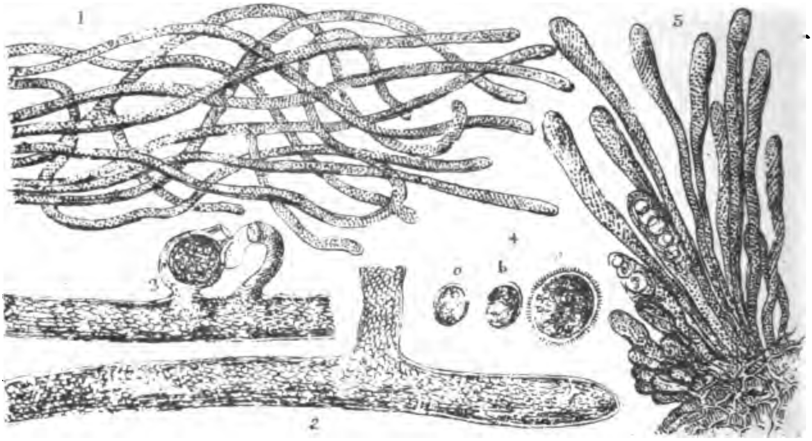
1. Oscillatoria autumnalis and allied species.
2. Microcoleus repens.
3. Lyngbya muralis.
4. Scytonema Myocrous.
5. Rivularia Boryana.

Nostochaceæ.

1. Nostoc commune. Several fragments showing vesicular cells to the left, and a filament in a gelatinous sheath to the right.

2. Trichormus musicola. The longer portion to the left exhibiting spermatic and vesicular cells, and the smaller segments to the right, the effect of treatment with acid.

SIPHONACEÆ.



ZYGNEMACEÆ.

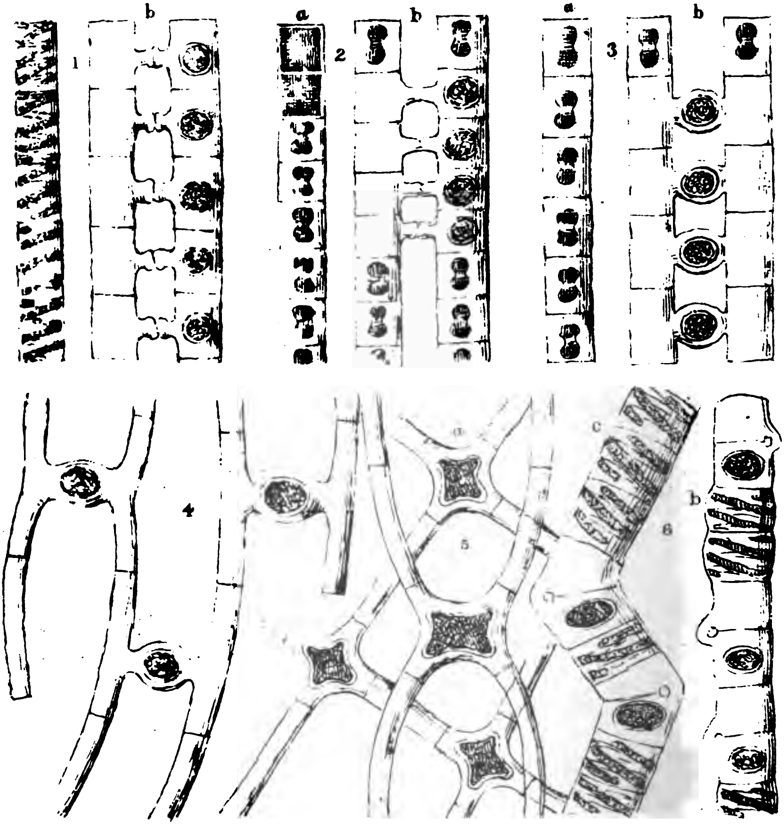


PLATE IX.

Siphonaceæ.

1. Vaucheria Ungeri. 2. Portion more highly magnified.

3. Sporange and antheridium. 4. *a* and *b* stages in the development of *c*, the ciliated spore of Vaucheria.

5. Achlya prolifera, with its mycelioid rootlets growing upon the dead body of a small fly.

Zygnemaceæ.

1. Spirogyra. 2. Zygnema. 3. Zygogonium.
In all three cases the simple filament is shown at *a*, and the mode of conjugation at *b*.

4. Mesocarpus. 5. Staurocarpus. 6. Rhynchonema. *a* and *b* in the two latter figures merely indicate different species.

CONFERVACEÆ (a & b) ŒDOGONIACEÆ (c & d) CHÆTOPHORACEÆ (e).

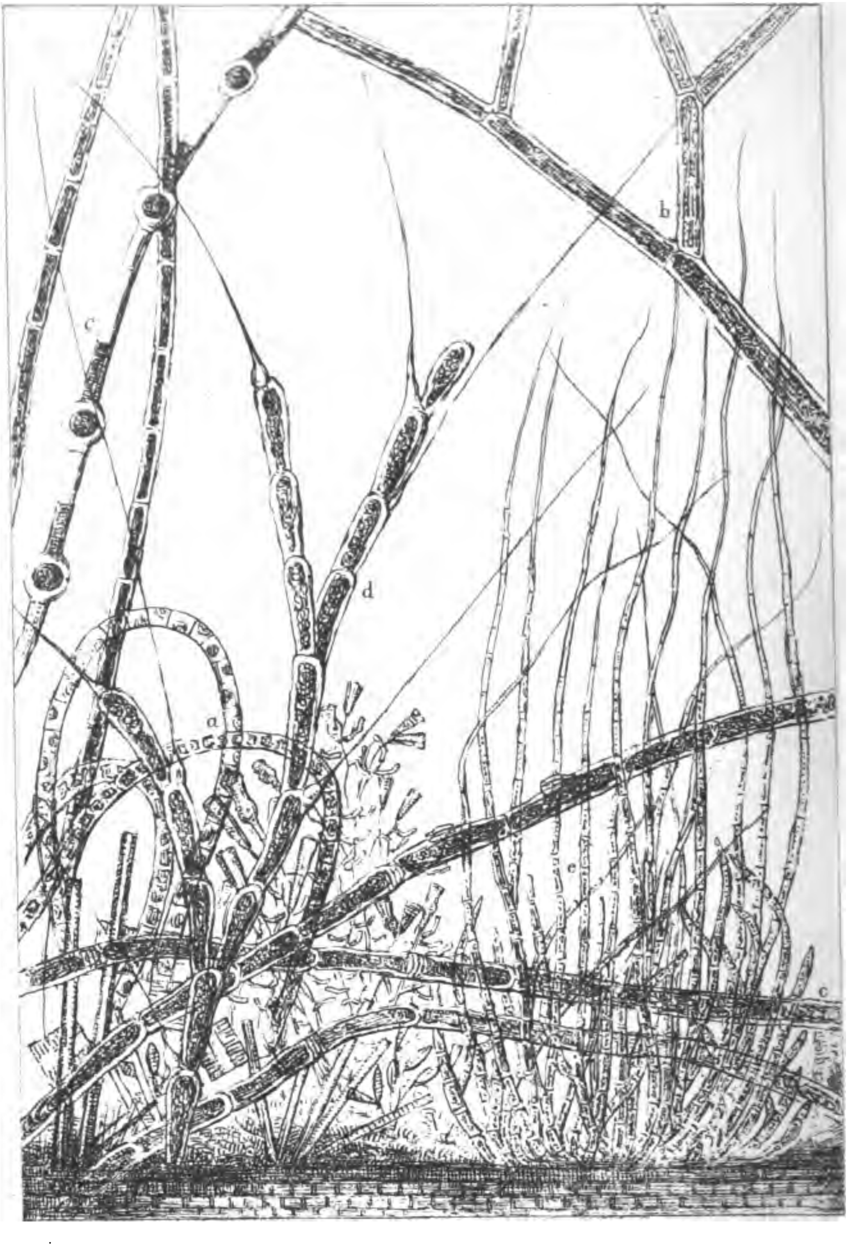
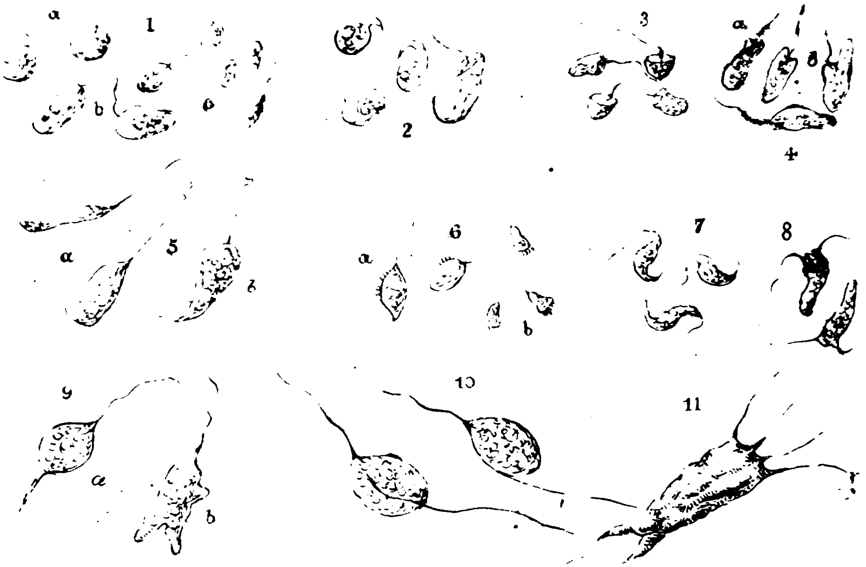


PLATE X.

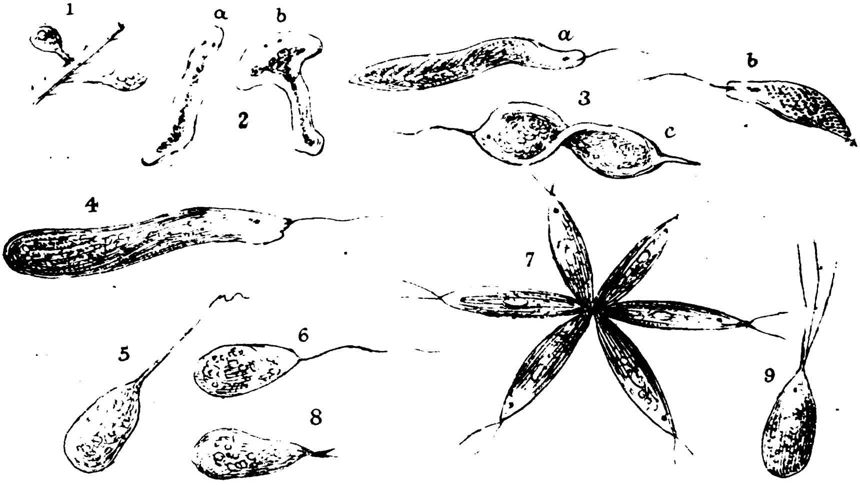
Confervaceæ, Œdogoniaceæ and Chætophoraceæ.

a. Conferva floccosa. *b.* Cladophora crispata. *c.* Species of Œdogonium. *d.* Bulbochæte setigera. *e.* Chætophora elegans. Amongst the Diatomaceæ introduced in this Plate may be noticed—Long prismatic Synedræ, Tabellaria floccosa, wedge-shaped and stalked Gomphonemæ, with the little bent frustules of Achnanthes minutissima. A spray of pond weed forms the theatre of this microscopic vegetation.

MONADACEÆ.



EUGLENACEÆ.



THECAMONADACÆ.

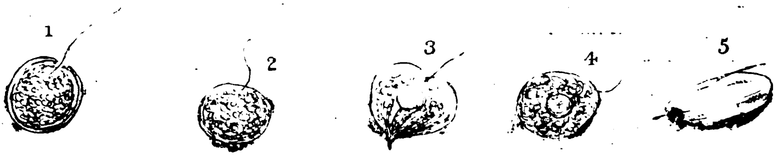


PLATE XI.

Monadaceæ.

1. Monas (*a*) gutula, (*b*) fluida, (*c*) cunillus. 2. Pleuromonas granulosa. 3. Cyathomonas (*a*) turbinata, (*b*) viridis. 4. Chilomonas (*a*) destruens, (*b*) obliqua. 5. Cyclidium (*a*) abscissum, (*b*) distortum. 6. Trichomonas (*a*) vaginalis, (*b*) minima. 7. Trepomonas agilis. 8. Amphimonas dispar. 9. Cercomonas (*a*) longicauda, (*b*) lobata. 10. Heteromita exigua in two positions. 11. Hexamita nodulosa.

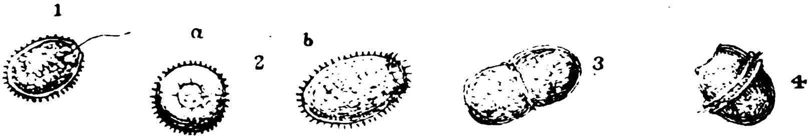
Euglenaceæ.

1. Colacium vesiculosum. 2. Distigma (*a*) proteus, (*b*) viride. 3. Euglena (*a*) spirogyra, (*b*) viridis, (*c*) longicauda. 4. Amblyophis viridis. 5. Peranema globulosa. 6. Astasia inflata. 7. Chlorogonium euchlorum. 8. Zygoselmis inæqualis. 9. Polyselmis viridis.

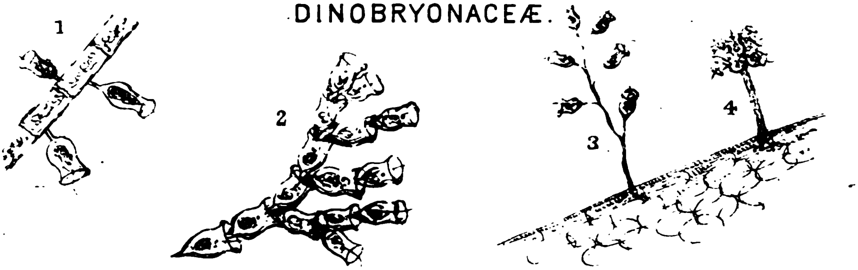
Thecamonadaceæ.

1. Trachelomonas volvocina. 2. Cryptomonas globulus. 3. Phacus pleuronectes. 4. Crumenula texta. 5. Anisonema sulcata.

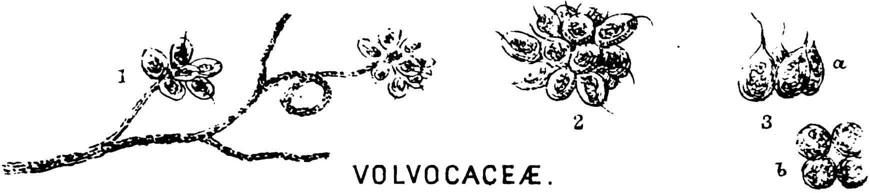
PERIDINIACEÆ.



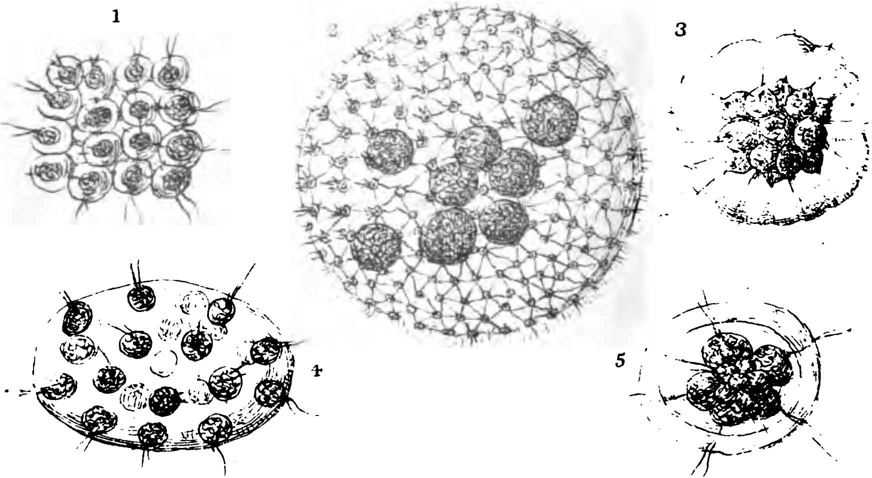
DINOBRYONACEÆ.



ANTHOPHYSACEÆ



VOLVOCACEÆ.



PROTOCOCCUS.

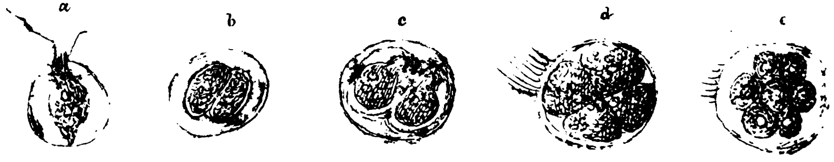


PLATE XII.

Peridiniaceæ.

1. Chætoglena sp. 2. Chætotyphla armata (*a*) end, and (*b*) side view. 3. Glenodinium cinctum. 4. Peridinium cinctum.

Dinobryonaceæ.

1. Epipyxis utriculus. 2. Dinobryon sertularia. 3. Stylobryon insignis. (Fro.) 4. Pycnobryon socialis. (Fro.)

Anthophysaceæ.

1. Anthophysa Mülleri. 2. Uvella virescens. 3. Tetrabæna Dujardini. (*a*) side view, (*b*) end view.

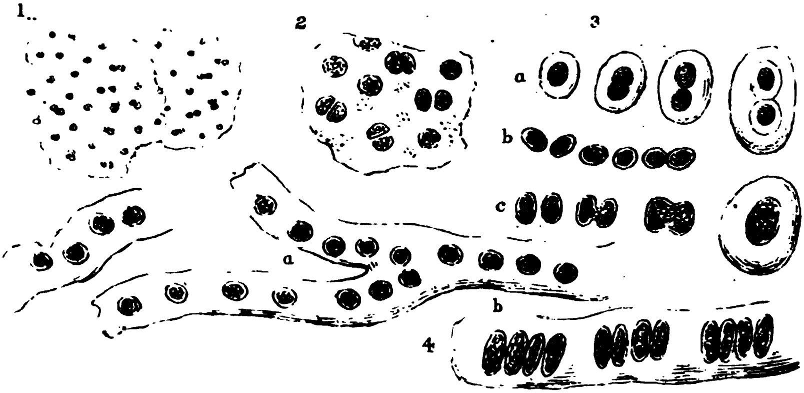
Volvocaceæ.

1. Gonium pectorale. 2. Volvox globator. 3. Pandorina morum. 4. Allodorina irregularis. 5. Diplodorina Massoni.

Transitional form, Protococcus viridis.

(*a*) Single motile cell; (*b*) stationary cell undergoing cleavage; (*c*) two resulting cells; (*d*) cleavage into four, &c.; (*e*) into eight new cells within the primary one.

PALMELLACEÆ.



TYPES OF DESMIDIACEÆ.

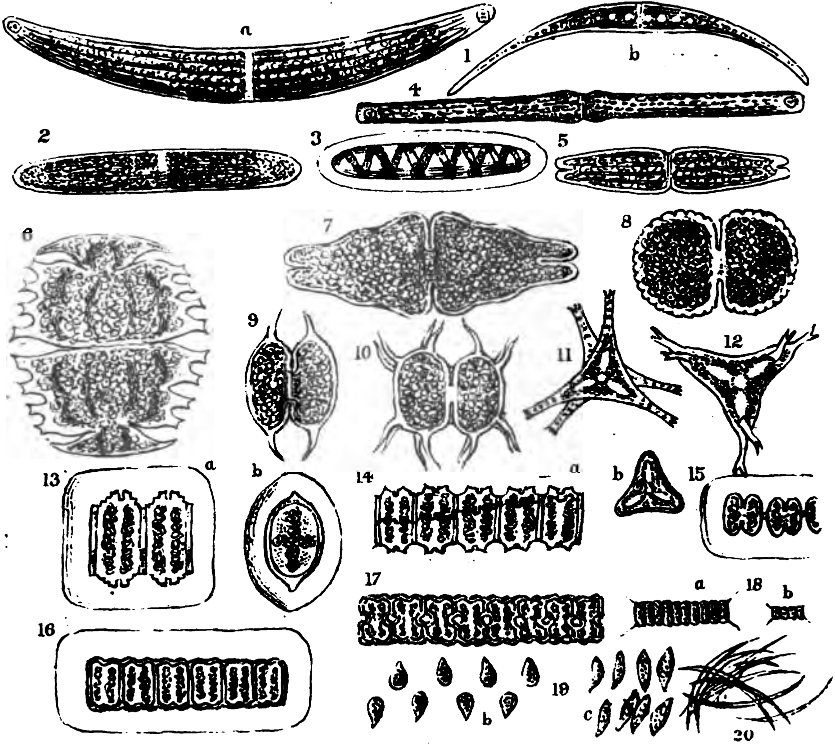


PLATE XIII.

Palmellaceæ.

1. Microhaloa ichthyoblabe. 2. Palmella cruenta.

3. Coccochloris Brebissonii. (*a*) Development and cleavage of a cell resulting in two new cells, each enclosed in a new gelatinous coat within the primary one. (*b*) Multiplication in the absence of the moisture necessary for the production of the gelatinous coat. (*c*) Approximation, union, and coalescence of two endochromes, to form a new cell, with the capability of repeating the process with a similar cell.

4. Hormospora (*a*) mutabilis, and (*b*) transversalis; which latter makes a near approach to some of the humbler Desmidiaceæ.

Types of Desmidiaceæ.

1. Closterium (*a*) lunula, (*b*) moniliformis. 2. Penium Brebissonii. 3. Spirotænia condensatum. 4. Docidium baculum. 5. Tetmemorus Brebissonii. 6. Micrasterias sp. (Fiji.) 7. Euastrum didelta. 8. Cosmarium margaritiferum. 9. Arthrodesmus convergens. 10. Xanthidium fasciculatum. 11. Staurastrum gracile. 12. Didymocladon furcigerus. 13. Didymoprium Grevillii (*a*) front, and (*b*) side-view. 14. Desmidium Swartzii (*a*) front, and (*b*) side-view. 15. Sphærozosma vertebratum. 16. Hyalotheca dissilens. 17. Aptogonum desmidium. 18. (*a* and *b*) Scenedesmus quadricornis. 19. (*b*) Scenedesmus obtusus, (*c*) S. obliquus. 20. Ankistrodesmus falcatus.

For the *Pediastreæ,* see Plate XV.

34 TYPES OF FRESH WATER DIATOMACEÆ.

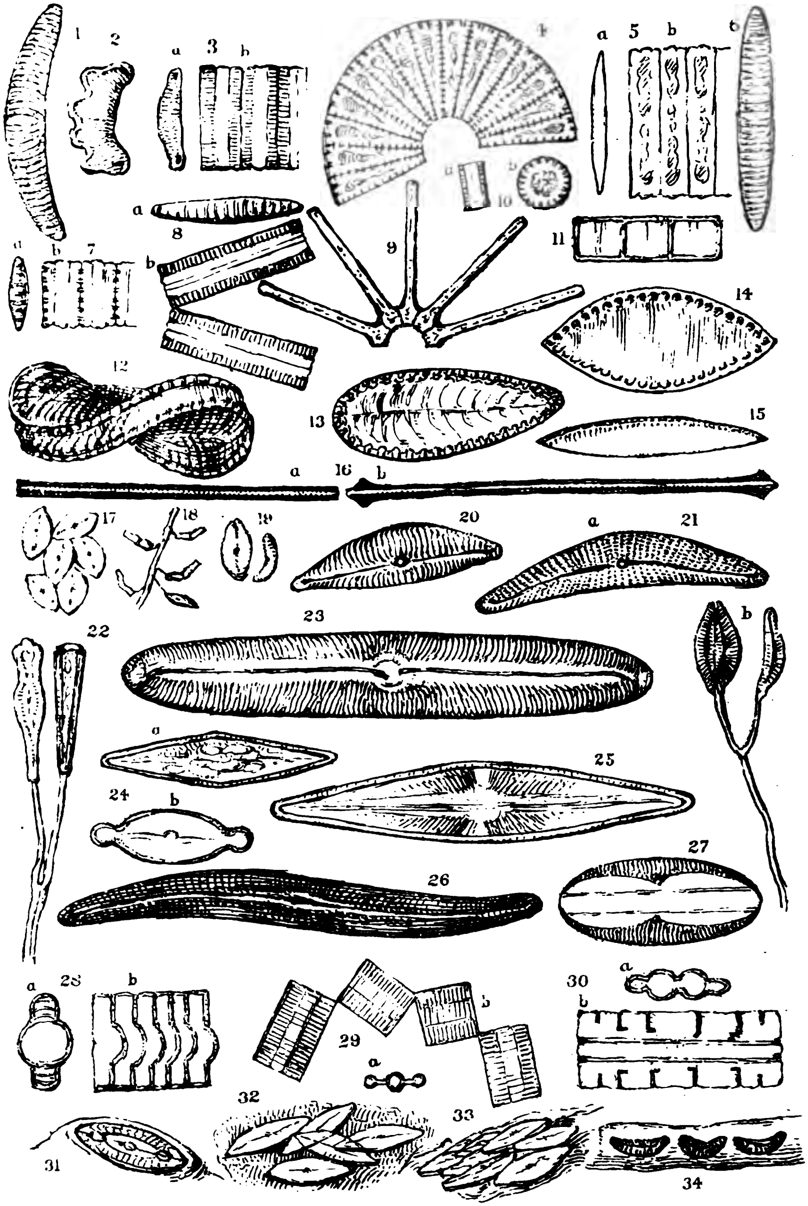


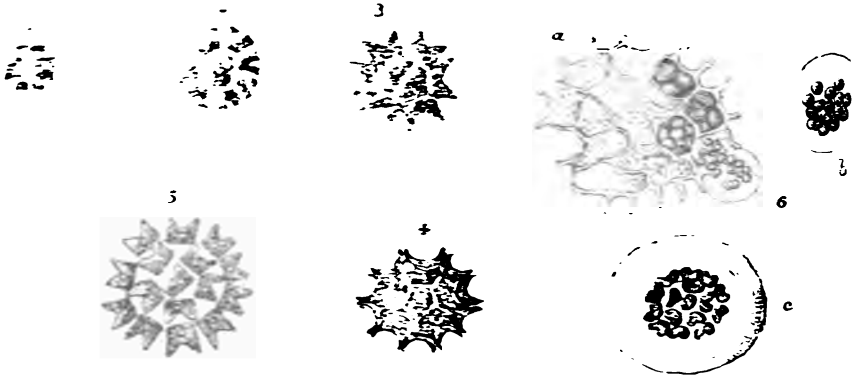
PLATE XIV.

Thirty-four Types of Fresh-Water Diatomaceæ.

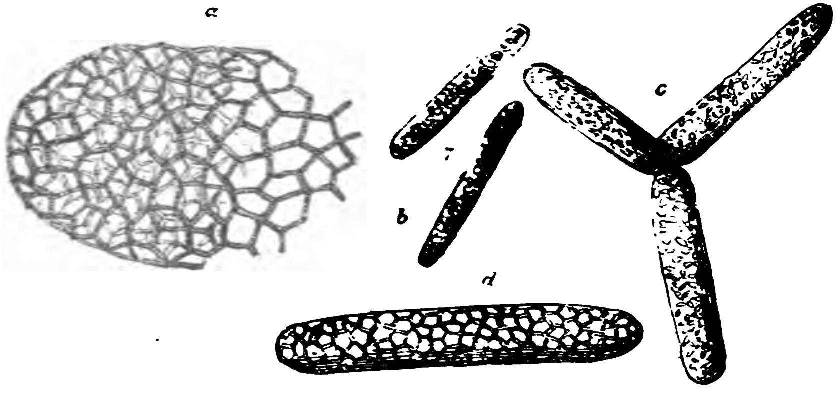
1. Epithemia turgida. 2. Eunotia tetraodon. 3. Himantidium pectinale (*a* side, and *b* front view). 4. Meridion circulare. 5. Fragilaria capucina. 6. Denticula elegans. 7. Odontidium turgidum (*a* side, and *b* front view). 8. Diatoma vulgare (*a* side, and *b* front view). 9. Astrionella formosa. 10. Cyclotella opercula. 11. Melosira varians. 12. Campylodiscus spiralis. 13. Surirella splendida. 14. Sphynctocystis elliptica. 16. Synedra (*a* splendens, *b* capitata). 17. Cocconeis pediculus. 18. Achnanthes minutissima. 19. Achnanthidium microcephalum. 20. Cymbella Ehrenbergii. 21. Cocconema lanceolatum, *a* and *b* (*a*, single frustule highly magnified). 22. Gomphonema acuminatum. 23. Pinnularia grandis. 24. (*a*) Navicula cuspidata, (*b*) N. sphærophera. 25. Stauroneis acuta. 26. Gyrosigma attenuatum. 27. Amphora ovalis. 28. Tetracyclus lacustris (*a* side, *b* front view). 29. Tabellaria floccosa (*a* side, *b* front view). 30. Terpsinoe musica (*a* side, *b* front view). 31. Mastogloia lanceolata. 32. Frustulia saxonica. 33. Colletonema vulgare. 34. Encyonema paradoxum.

Pl. XV.

PEDIASTREÆ.



HYDRODICTYON.



APIOCYSTACEÆ.

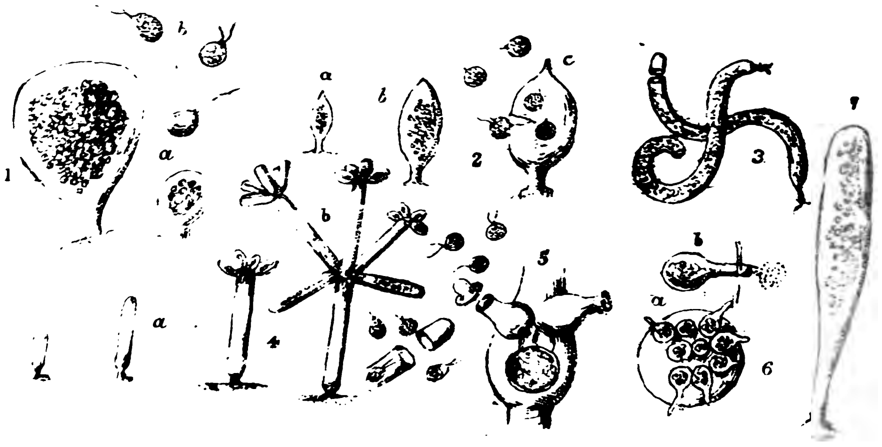


PLATE XV.

Pediastreæ.

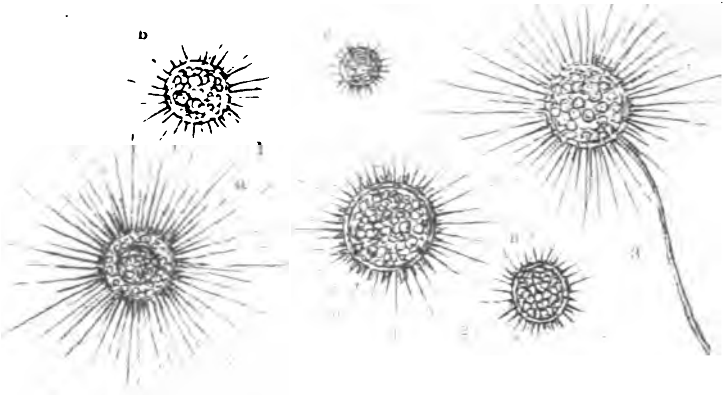
1. Pediastrum tetras. 2. Pediastrum simplex. 3. Pediastrum hexactis. 4. Pediastrum tricyclium. 5. Pediastrum lunare. 6. Pediastrum granulatum. (*a*) shows a disc from which gonidia are still escaping, the greater number of the cells having been already emptied in this way. (*b*) a new family just forming, (*c*) more advanced stage, the gonidia beginning to take a definite form. Hydrodictyon utriculatum. (*a*) portion of H. utriculatum showing its general structure, (*b*) two of the component cylindrical cells separated from the organism, (*c*) three of the same connected at one end and showing the gonidia within, preparatory to their union so as to form a new colony, as seen at (*d*), which is one of the cells more advanced in development and more highly magnified.

Apiocystaceæ. (Provisional.)

1. Apiocystis Brauniana (*a* young, *b* zoospore). 2. Hydrocytium acuminatum (*a*, *b* stages of growth, *c* shedding zoospores). 3. Ophiocytium majus. 4. Sciadium arbuscula (*a* stages of development, *b* complete form). 5. Chytridium Olla, on a filament of Œdogonium, one dehiscing and discharging monad-like zoospores. 6. Pythium entophytum (*a* an immature cluster in a cell of Chlorosphæra, *b* one perforating the cell-wall and discharging its contents). 7. Codiolum gregarium.

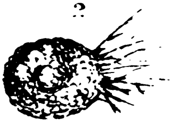
RHIZOPODA.

RADIOLARIA.

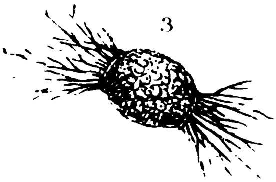


1. *Actinophrys.* 2. *Acanthocystis* 3. *Clathrulina.*

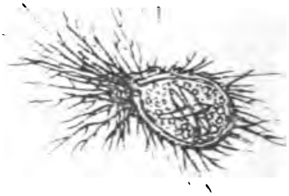
RETICULARIA



Pleurophrys

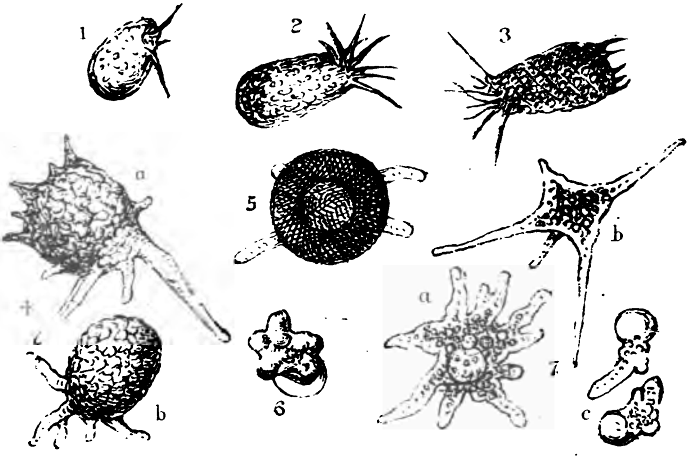


Amphitrema.



Gromia.

LOBOSA



1. *Trinema acinus* 2. *Euglypha tuberculata.* 3. *E. alveolata.*
4. *Difflugia, two forms.* 5. *Arcella Vulgaris, from above.* 6. *Cyphidium.* 7. *Amœba, several forms.*

PLATE XVI.

Rhizopoda.

Radiolaria.

1. Actinophrys; (*a*) Eichornii; (*b*) sol.; (*c*) ditto young. 2. Acanthocystis turfacea; (*a*) full grown, (*b*) young. 3. Clathrulina elegans.

Reticularia.

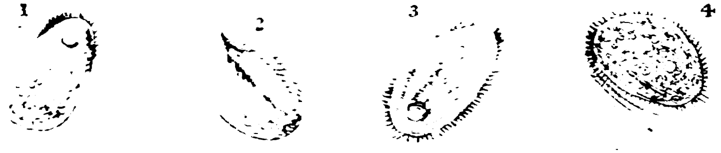
1. Gromia fluviatilis. 2. Pleurophrys amphitremoides. 3. Amphitrema Wrightianum.

Lobosa.

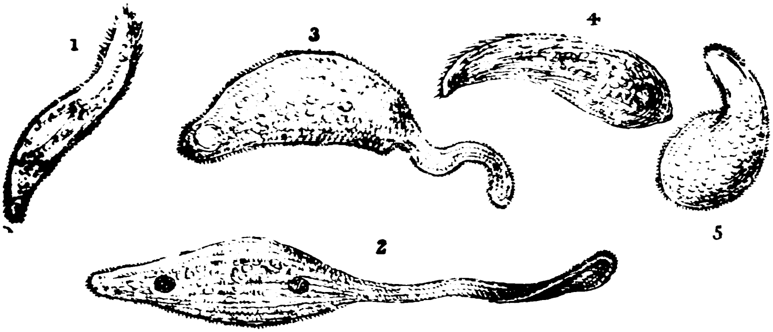
1. Trinema acinus. 2. Euglypha tuberculata. 3. E. alveolata. 4. Difflugia (*a*) spinosa, (*b*) proteiformis. 5. Arcella vulgaris. 6. Cyphidium aureolum. 7. Amœba, (*a*) ramosa, (*b*) radiosa, (*c*) young of diffluens.

CILIATA

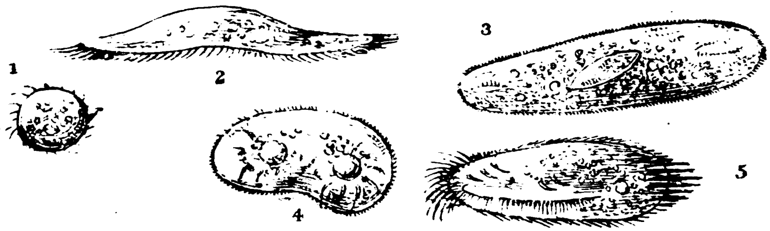
ENCHELIA.



TRICHODINA.



KERONIA.



EUPLOTA.

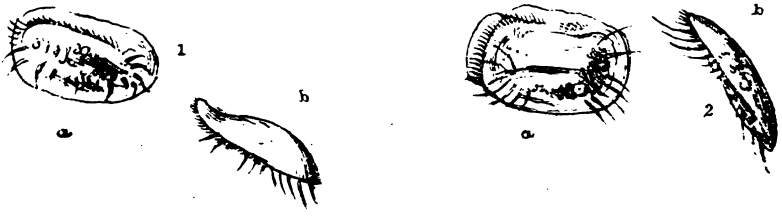


PLATE XVII.

Ciliata.

Enchelia.

1. Acomia vitrea. 2. Gastrochæta fissa. 3. Enchelys nodulosa. 4. Alyscum saltans.

Trichodina.

1. Pelecida rostrum. 2. Dileptus folium. 3. Trachelius anas. 4. Acineria incurvata. 5. Trichoda angulata.

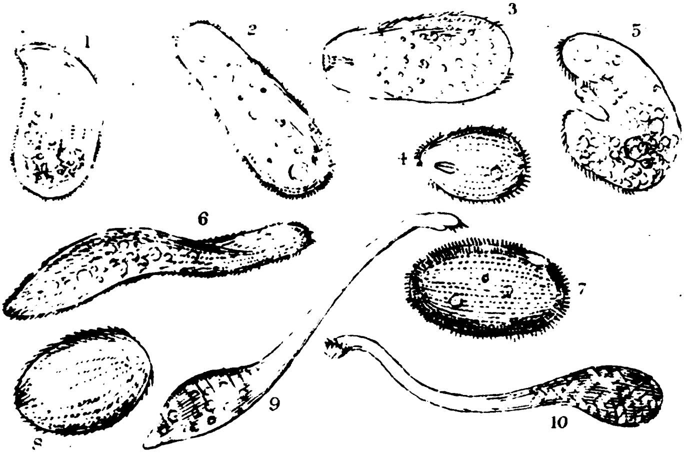
Keronia.

1. Halteria grandinella. 2. Oxytricha gibba. 3. Urostyla grandis. 4. Kerona polyporum. 5. Stylonychia histrio (lanceolata ?).

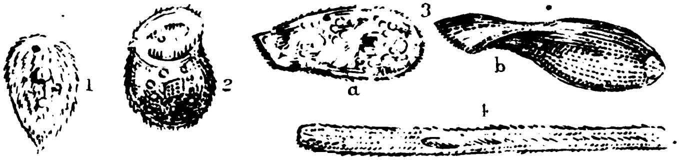
Euplota.

1. Himantophorus charon; (*a*) front, and (*b*) side view. 2. Euplotes vannus, (*a*) front, and (*b*) side view.

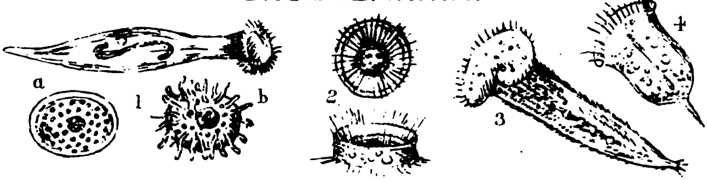
CILIATA (*Cont^d*) PARAMECIA.



BURSARINA.



URCEOLARINA.



VORTICELLINA.

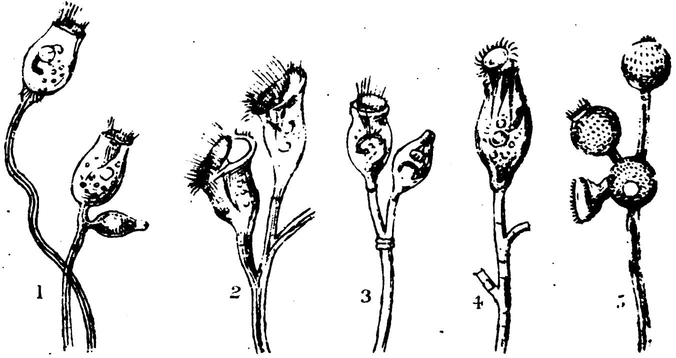


PLATE XVIII.

Ciliata.

Paramecia.

1. Chilodon cucullulus. 2. Nassula elegans. 3. Prorodon teres. 4. Glaucoma scintillans. 5. Colpoda cucullus. 6. Paramecium aurelia (three-quarter-view). 7. Panophrys crysalis. 8. Holophrya ovum. 9. Trachelocerca olor. 10. Lacrymaria proteus.

Bursarina.

1. Ophryoglena acuminata. 2. Bursaria vorticella. 3. Leucophrys (*a*) patula, (*b*) spathula, Ehr. (Spathidium hyalinum) Du. 4. Spirostomum ambiguum.

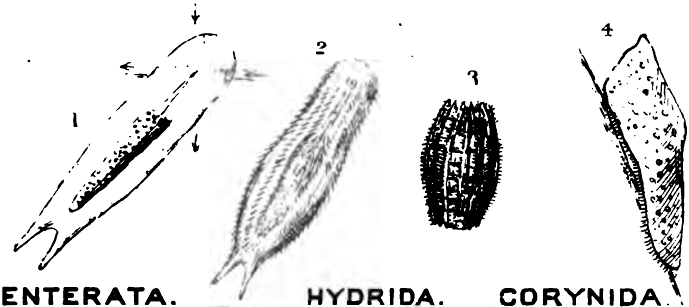
Urceolarina.

1. Ophrydium versatile, showing an animal in the extended state, and (*a*) encysted, (*b*) the supposed Acineta form. 2. Urceolaria pediculus (Trichodina). 3. Stentor cœruleus, with internal germs. Urocentrum turbo.

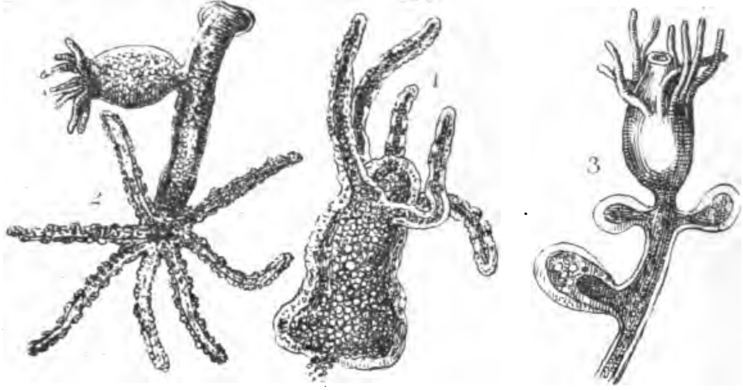
Vorticellina.

1. Vorticella microstoma. 2. Carchesium polypinum. 3. Epistylis crassicollis. 4. Opercularia articula. 5. Zoothamnium arbuscula.

CILIATA (Cont^d) SYMMETRICAL FORMS.



CŒLENTERATA. HYDRIDA. CORYNIDA.



SCOLECIDA. TURBELLARIA

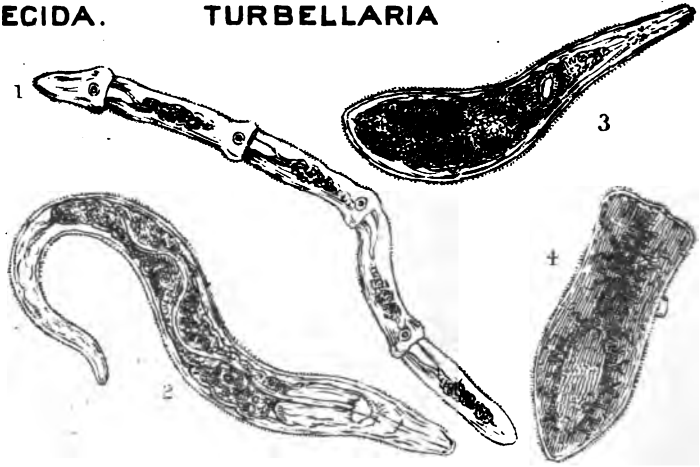


PLATE XIX.

Ciliata.

Symmetrical Forms.

1. Ichthydium Podura. 2. Chætonotus Larus. 3. Coleps hirtus. 4. Planariola rubra.

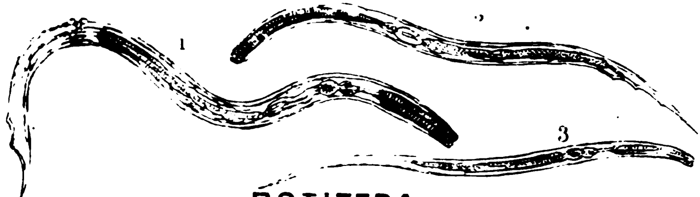
Cœlenterata.

1. Hydra viridis. 2. H. vulgaris. 3. Cordylophora lacustris.

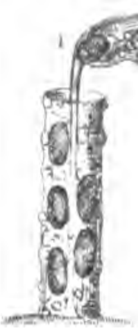
Turbellaria.

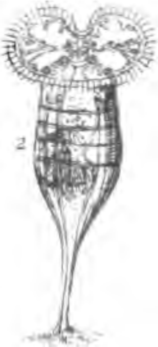
1. Derostomum. 2. Prostomum. 3. Mesostomum. 4. Planaria.

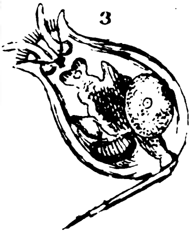
SCOLECIDA *(Contd.)* NEMATODA.

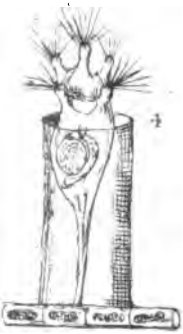


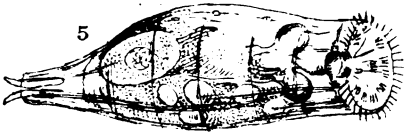
ROTIFERA.

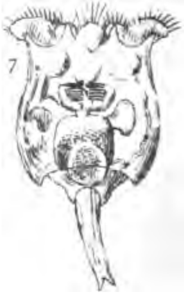


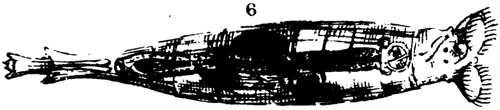












ANARTHROPODA. ANNELIDA.

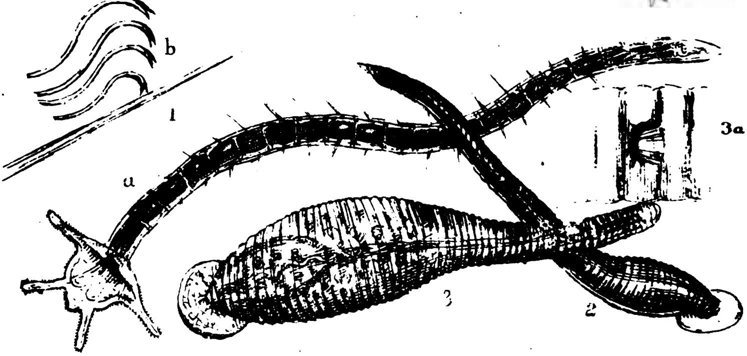


PLATE XX.

Nematoda.

1. Anguillula (from bilge water). 2. A. aceti. 3. A. fluviatilis.

Rotifera.

1. Œcistes crystallinus. 2. Megalotrocha flavicans. 3. Monostyla quadridentata. 4. Floscularia ornata. 5. Hydatina senta. 6. Rotifer vulgaris. 7. Brachionus amphiceros.

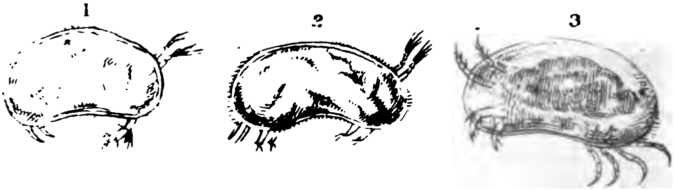
Annelida.

1. Naïad; (*a*) conformable with the Proto of Oken; (*b*) setæ, and ventral hooklets. 2. Nephelis, sp. 3. Glossiphonia bioculata; 3*a*. a dorsal chitinous tooth-like process directed backwards from the eleventh segment, over a little pit in the twelfth.

Pl. XXI.

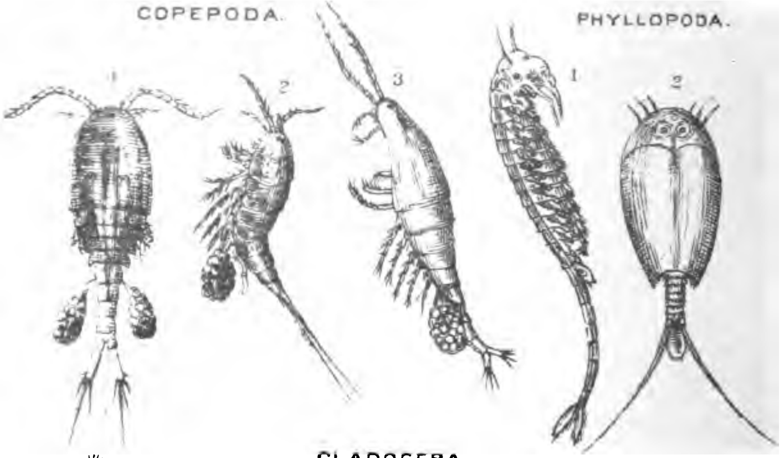
ENTOMOSTRACA.

OSTRACODA.



COPEPODA.

PHYLLOPODA.



CLADOCERA.

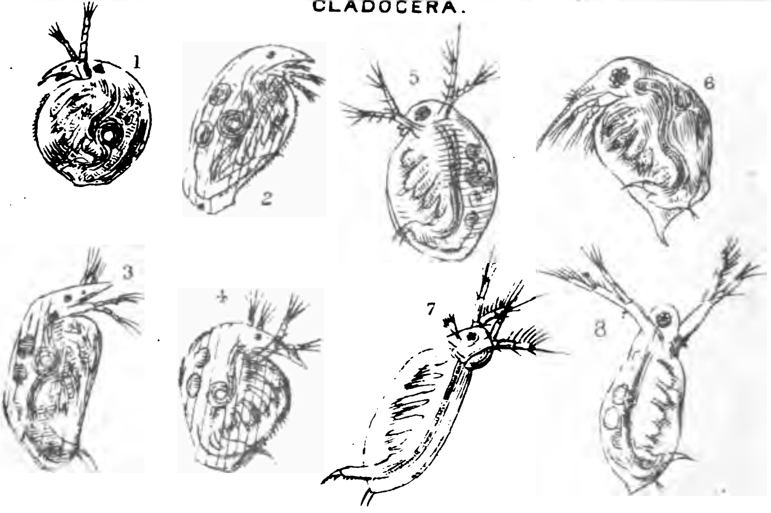


PLATE XXI.

Entomostraca.

Ostracoda.

1. Cypris tristriata. 2. Candona reptans. 3. Cythere inopinator.

Copepoda.

1. Cyclops quadricornis. 2. Canthocamptus minutus.
3. Diaptomus castor.

Phyllopoda.

1. Branchipus stagnalis. 2. Lepidurus, *Leach* = Monoculus Apus of *Linnæus.*

Cladocera.

Lynceidæ.

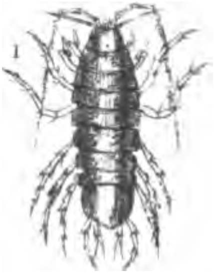
1. Chydorus sphæricus. 2. Camptocercus macrourus.
3. Alona quadrangularis. 4. Pleuroxus trigonellus.

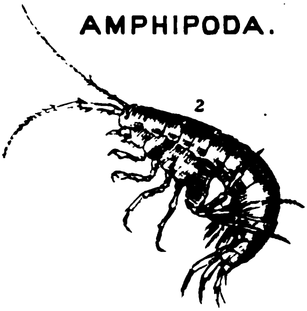
Daphnidæ.

5. Daphnia pulex. 6. Bosmina longirostris.
7. Sida crystallina. 8. Daphnella Wingii.

ISOPODA.

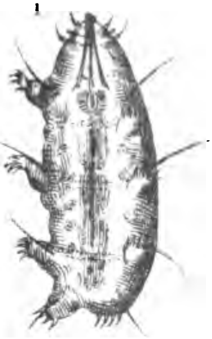
AMPHIPODA.

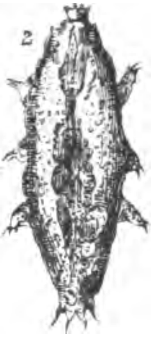


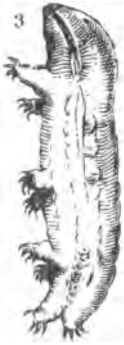


ARACHNIDA.

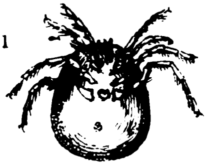
TARDIGRADA.

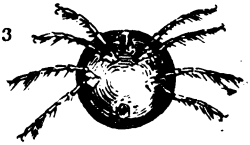


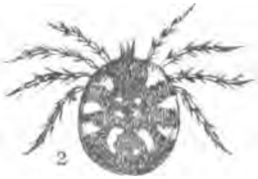




ACARINA.







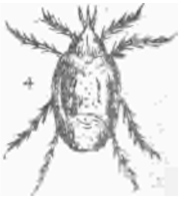


PLATE XXII.

Malacostraca.

Isopoda.	1. Asellus aquaticus.
Amphipoda.	2. Gammarus pulex.

Arachnida.

Tardigrada.

1. Emydium testudo. 2. Milnesium tardigrada.
3. Macrobiotus Hufelandii.

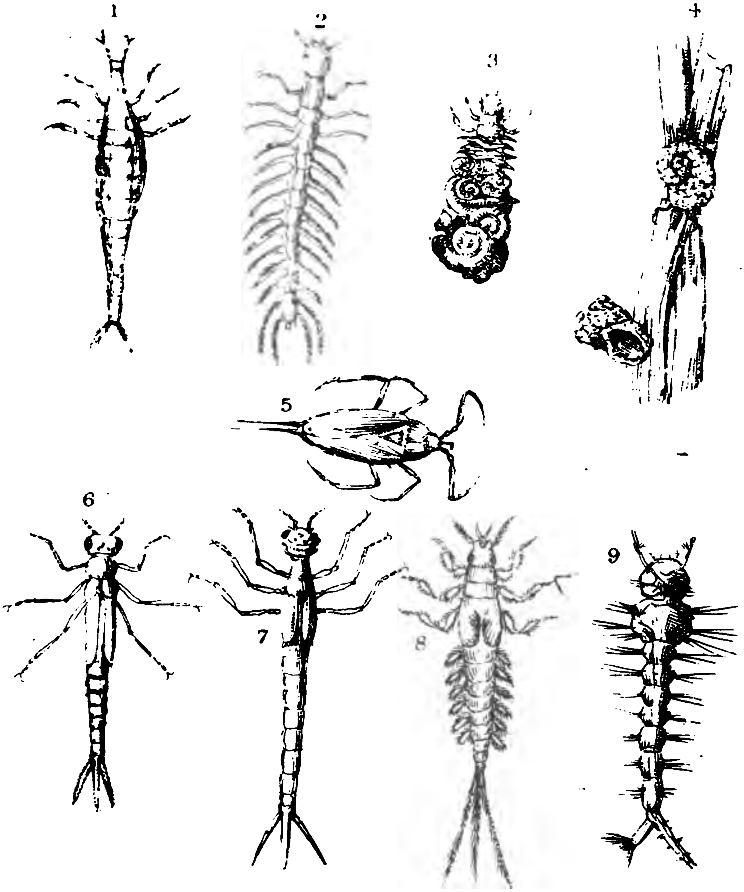
Acarina.

1. Hydrachna globula. 2. H. geographica.

3. A more globular form in which, quite exceptionally, six eyes are present.

4. Limnochares holocericus, a crawling water mite.

INSECTA.



OVA OF ENTOZOA.

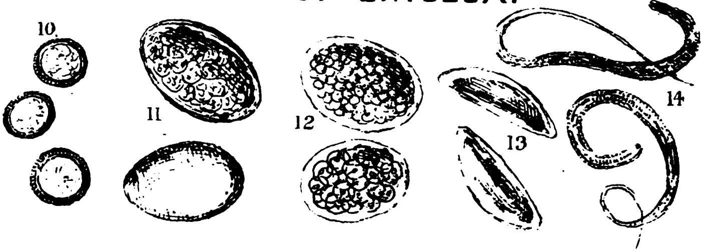


PLATE XXIII.

Insecta.

Coleoptera.

1. Larva of Acilius sulcatus.
2. Larva of Gyrinus natator.

Trichoptera.

3. Phryanea grandis in its composite case.
4. The form named *Thelidomus* by Mr. Swainson, who mistook the little built-up case for a genuine shell, and gave it a place among the Helices (snails), arranged in accordance with the "quinary system."

The case figured, from the Isle of Pines, S. W. Pacific, was made of granules of ironstone, but in some of the streams of New Caledonia, the retreat of probably the same species, is constructed of little amethysts.

Hæmiptera.

5. Pupa of Nepa (water scorpion).

Neuroptera.

6. Pupa of Agrion puella.
7. Pupa of Calepteryx virgo.
8. Pupa of Ephemera vulgata.

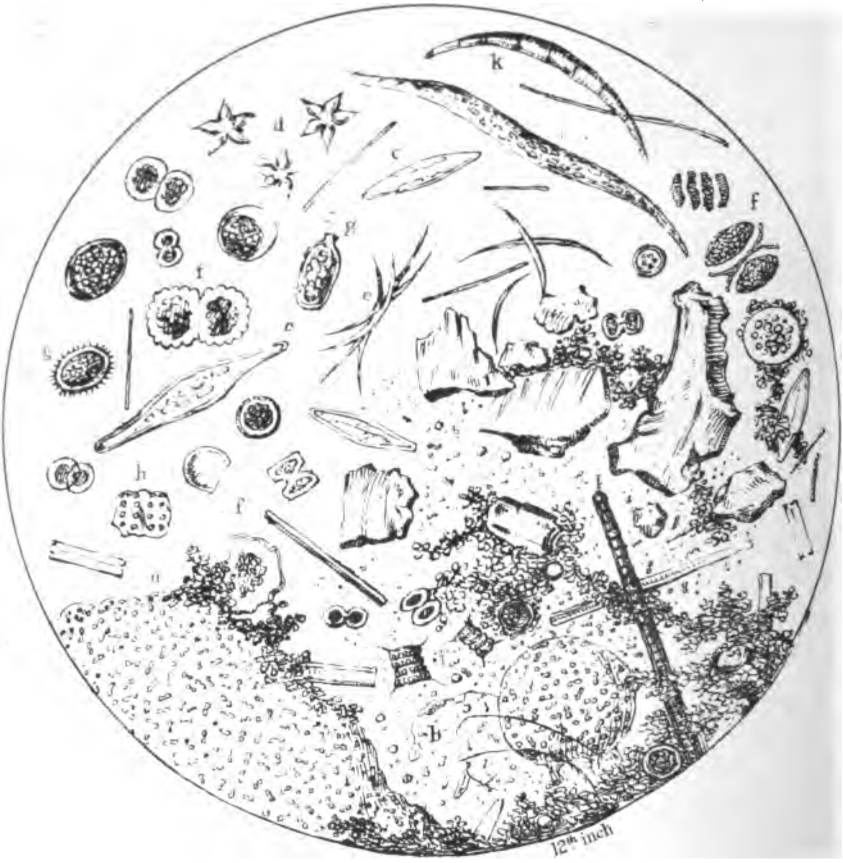
Diptera.

9. Larva of the Gnat Culex pipiens.

Ova of Entozoa.

10. Of Tænia mediocanellata.
11. Of Fasciola hepatica.
12. Of Ascaris dentata.
13. Of Bilharzia hæmatobia.
14. Young of Filaria medinensis.

WELL-WATER (NETLEY).



a. *Gelatinous fronds with Bacteria.*
b. *Monadina.*
c. *Diatomaceæ.*
d. *Star shaped cells*
e. *Ankistrodesmus.*
f. *Desmidiaceæ.*
g. *Thecomonadina.*
h. *Palmella, (minute.)*
i. *Euglena viridis.*
k. *Spore of Septoria, (fungus).*
l. *Oscillatoria.*

PLATE XXIV.

Well-Water (*Netley*).

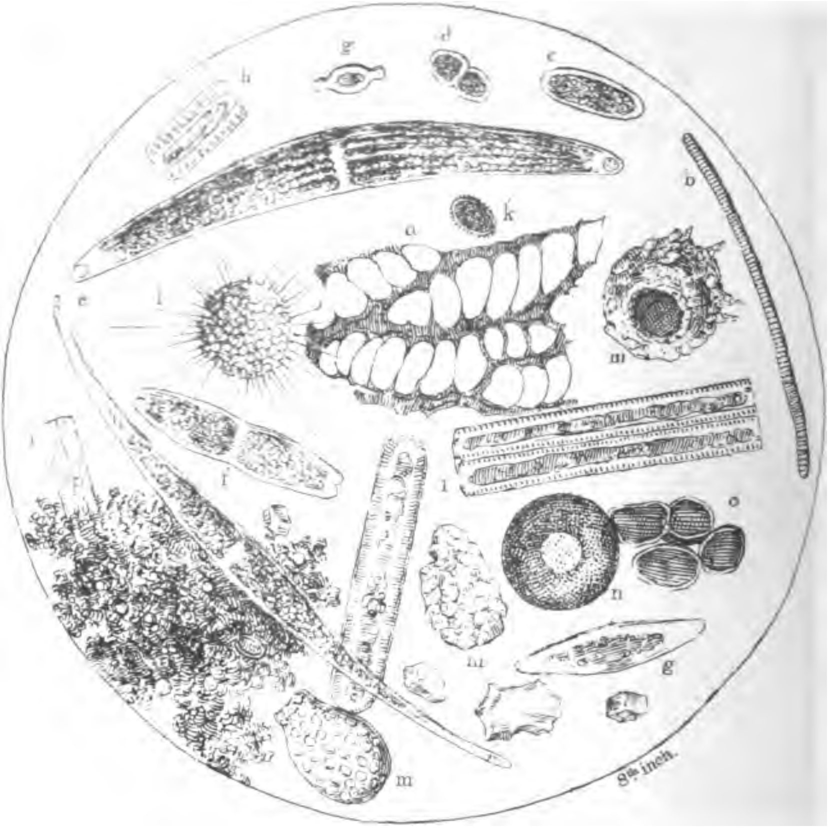
The suspended matters represented in this Plate were obtained by setting aside a tall glass litre measure full of the water, with a disc of glass attached to a long wire at the bottom. During the first twelve hours a deposit of grosser particles was formed, with a delicate coating here and there of the gelatinous matter and bacteroids shown at *a*. In twelve hours more this coating had become more consistent, and at the end of forty-eight hours was so firmly adherent as to require some force to remove it, with the mineral particles, resting-spores of algæ, and organic débris of different kinds embedded in it.

In the little bays and creeks of this gelatinous substance the loosened and detached Bacteria were in active motion, and interspersed with Monads (*b*) of minute size.

Navicula, Synedra, and other Diatoms (*c*), were free in the field, or often projecting from the amorphous débris. The little green star-like bodies (*d*) probably allied to the Tetrapedia, have also been noticed in other specimens obtained from a deep source, and are evidently identical with those figured in Plate IV., illustrating the Reports made to the Directors of the London (Watford) Spring-Water Company by Drs. Lankester and Redfern.

The remaining objects are sufficiently explained in the references attached to the Plate.

BOG-WATER.



a. *Particle of bog moss.*
b. *Oscillatoria.*
c. *Penium.*
d. *Cosmarium.*
e. *Closterium.*
f. *Tetmemorus.*
g. *Navicula.*
h. *Surirella.*
i. *Pinnularia.*
k. *Chætoglena.*
l. *Actinophrys.*
m. *Difflugia.*
n. *Arcella.*
o. *Brown Vegetable cells.*

PLATE XXV.

Bog Water.

The specimen of water here represented was taken from the swampy ground near Miller's Pond, Sholing, Southampton. It was very rich in Rhizopoda, Infusoria, Oscillatorians, and Desmids large and small, and the beautiful Pinnularia grandis, which is so plentiful in all the surrounding district, but chiefly in stagnant and impure water.

MICROSCOPICAL EXAMINATION OF DRINKING WATER.

INTRODUCTION.

ALTHOUGH the microscopical examination of drinking water may, in one sense, be regarded as an abstract question, if any important deductions are to be drawn from the study, not only the nature of the source of the samples, and the mode of collection, but the vessels used for their conveyance, should be taken into consideration.

Just as the mineral débris would afford us a clue to the nature of the strata or soil through which the water may pass, so the known habitat of certain organisms detected should enable us, in a general way, to determine whether the water had been taken from a river, stream, lake, pond, or well source. Indeed, if we were more perfectly acquainted with the natural history of the forms occurring in a sample of water, even in the absence of more definite information, we would have little difficulty in forming a conclusion as to the source from whence the water was derived.

It is always important that we should guard against every shadow of fallacy in our conclusions drawn from microscopical observation, to whatever hygienic purpose it may be subservient. Indeed, as absolute purity and cleanliness are required in all delicate chemical operations, so all our apparatus for microscopy should be microscopically clean, so to speak.

In relation to the apparatus just mentioned, some few remarks may be of use to the beginner.

As it is only in the mode of collecting the objects for observation that any essential difference exists in the method of examination applicable to air and water, the reader is referred to the Appendix for the means to be employed in the case of air.

Collecting bottles for water.—When a sample of water is received for chemical analysis, it is usual to reserve a portion, with the sediment at the bottom of the bottle, for microscopical examination. It will therefore be seen how necessary it is that bottles in which samples are conveyed should be perfectly clean in the first instance, and in every other particular suitable for the purpose. In the laboratory of the Army Medical School, where a large amount of water analysis is continually carried on, it has been decided not to examine any samples sent in ordinary wine bottles or stone jars closed with corks and sealing-wax, corn-cobs, or other adventitious materials, with which there must always be some fallacy associated. Clear glass-stoppered Winchester quarts, so called, which are cheap enough, are therefore recommended for this purpose, and commonly used, with others of a larger size if available.

Tall glass vessels for the deposit of suspended matters.—Though a litre or half-litre measure glass would answer very well, there can be no doubt that a special vessel closed with a glass stopper would be more suitable for this purpose. The mouth of the vessel, however, should be sufficiently large to admit of its being easily and thoroughly cleaned before use.

Moderately tall conical glasses for the further concentration of sediment.—Such glasses as are used for the collection of urinary deposits will answer this purpose, but the interior of the bottom, though small, should be rounded, and not acuminately conical, which in some instances will scarcely admit of being cleaned, especially if a former sediment has been permitted to dry within it. When glasses of this kind are only carelessly rinsed out, the tabulated results of a subsequent examination cannot be reliable.

Dipping tubes or pipettes.—These tubes should be quite cylindrical in form—in fact, simple glass tubing cut in lengths of eight or ten inches. The lumen or bore should be comparatively small—say, the eighth or tenth of an inch in diameter. If the tube is too large, and with a small aperture below, the contained air will materially affect the ascent of the fluid with the sediment. On this account it is often difficult to manage the pipettes that are made with the greatest care. The ends of a piece of glass tubing cut in the usual way should be smoothly ground or slightly fused, and rounded by means of a blowpipe, to obviate the minute chipping of the glass, which is often a source of fallacy.

It may be well to mention here, as a good precaution, that every separate sample of water for observation should have a separate pipette for taking up the sediment. When the same pipette is used for every purpose, even with what might be thought to be a clean rinse for every new occasion, any evidence deducible from the last, or indeed any observation under such circumstances, would be inadmissible. In this way, for example, striped muscle and fibrous tissue have been reported as occurring in drinking water, which had otherwise been found to be quite free from organic impurity; the fact being that the pipette employed had been previously used in the examination of a certain form of beef-tea, from which even the clean rinse had not entirely divested it.

The slides and covering glasses required for more immediate examination of specimens need no special remark in this place, further than to say that for rough materials it will be more convenient to use thick covers that may be easily cleaned without breaking them; while for finer materials, and especially for immersion purposes, they should be proportionately thin.

Mode of Collecting Sediments and placing them under the Microscope—Microscopical Powers—Immersion-lenses.

When water is very turbid, from an obviously impure source, it is easy enough to obtain a sufficient amount of sedimentary matter for microscopical examination, and a just estimate of the unfitness of such water for drinking purposes may be thus readily formed. But it more frequently happens that the deposit, even after long standing, is but slight, and when this is the case, we must have recourse to special means, by which the whole, or a large amount of the matters in suspension, may be concentrated, or collected together, within a small compass. In the first place, one of the tall glass vessels above described should be filled with the water to be examined, and a circular disc of glass, resting on a horizontal loop at the end of a long aluminium wire lowered to the bottom, when the whole arrangement, lightly covered, must be set aside for twenty-four or forty-eight hours, as the case may be.

At the end of the specified time, the water should be siphoned off with a piece of india-rubber tubing, so as to leave only a thin stratum of the liquid over the glass disc. This should now be carefully raised and laid upon blotting-paper to dry its under surface and remove the surplus moisture, when it may be at once transferred to the microscope, with a large piece of covering glass so placed upon it as to exclude all air-bubbles. An ordinary watch-glass may in some cases be substituted for the disc alluded to, with advantage, as being less likely to permit the loss of sediment by overflow, which is certain to happen with a plain surface. The operator must be cautioned not to use iron wire, which rusts so rapidly that it will soon throw down a flocculent precipitate. Another good plan, which is perhaps the better of the two, is to siphon off the water until only a sufficient quantity remains to permit the sediment to be shaken up with it, and poured into a tall conical glass, from which, after standing again for a short time, portions may be taken up by means of a pipette, and placed on slides for examination. If the subsidence is observed to be complete, it is rather an advantage to have a good body of water in the glass, or, at least, so much as will permit the pipette to be used with ease and facility. It may be observed here, that it is very inconvenient to have too much fluid at a time on a slide. The covering glass will be unstable and liable to have its upper surface wetted, while the objects themselves will be tremulous, if they do not quite run out of the field. To obviate this, the pipette, when taken out of the water, should be held in a vertical position for some little time, until the suspended matters gravitate to the bottom of the tube, when a well charged droplet might be placed on a number of separate slides and examined seriatim. This is, in fact, the only way in which a large sediment can be thoroughly inspected.

By the second method above mentioned, the specimen of well-water sediment represented in Plate XXIV. was prepared. The gelatinous matter, developed round the bacteria-like cells at the lower part of the drawing (*a*) was only loosely adherent at the close of the first day; but, subsequently to this, or during the next forty-eight hours, it formed a delicate but perfect incrustation at the bottom of the vessel. Many of the little bodies detached from the gelatinous frond were seen in active motion in the immediate vicinity. More definite fronds, with still more minute bacteriform bodies growing upon a decomposing spray of pond-weed, are shown in Plate VII., as seen with a sixteenth of an inch immersion-lens. The first of these forms, at least, would seem to exhibit an alliance with the *Palmellaceæ,* while others, which are very readily confounded with them, show a marked affinity to the *Oscillatorians* (see further remarks on this subject under the head of *Bacteriaceæ*). It will be apparent, from the foregoing observations, that the sediments of comparatively clear water require the very highest microscopical powers for their investigation, and the employment of immersion-lenses if available.

Filamentous Algæ, as narrow as true bacteria, may be thus frequently brought into view, as well as the delicate flagellæ, or locomotive organs of monads, whose bodies alone would be scarcely visible with lower powers. It is also important to mention that, by these means, even in the absence of ordinary amœbæ, particles of protoplasm of bacterium size, exhibiting amœbiform movements, are often discernible. Lastly, very finely-divided mineral matter in suspension, giving rise to milkiness or haze, can only be studied with immersion-lenses, though certain cases may occur in which no objective cause of this condition can be detected microscopically.

Mineral matters of various hues in the soil, through or over which water percolates or flows, are the more usual causes of discoloration and turbidity. Peroxide of iron, in particular, may be mentioned as the source of the brown cloudy appearance of water from the blue clay, as also, frequently, of the brown colour of pools in bog-lands, though this more usually arises from organic matter passing into decay. In the coarser sediment under such circumstances, the microscopic forms of animal and vegetable life are likely to be abundant (viz., *Rotifera, Infusoria, Rhizopods, Oscillatorians, Nostocs, Desmids* and *Diatoms*). In ferruginous bog-water also the twin-spiral filaments of *Didymohelix,* invested with a yellowish-brown gelatinous matter, and *Leptothrix ochrea,* a rather ill-defined myceloid structure, may add to the general effect. By reflected light, moreover, the fine amber tint of the *Diatomaceæ,* floating or resting, is quite brown. Some of the heterogeneous materials usually occurring in bog-water are represented in Plate XXV.

SECTION I.

MINERAL MATTERS. (Plate I.)

MINERAL matters in suspension in water often give a turbidity of a colour and character indicative of their nature. When the particles are large, they will descend more rapidly; but when very subtle or minutely divided, the suspension being more complete, a longer time will be required for their subsidence. Looking down through a considerable depth of the water, with the glass vessel containing it resting on a white ground, will afford some preparatory information; especially when compared with a stratum of pure water in a second vessel observed in a similar way.

Haziness, or peculiarity of colour, may be thus detected, which would be quite inappreciable in a thin layer. With a long glass tube, a stratum of two or more feet might be obtained; a method also valuable in observing the effect of reagents or tests in water. In the light of preparatory information, it may be stated, moreover, that sandy particles or clay in suspension give a yellowish-white turbidity; and on boiling the water, as Professor Parkes observes, "sand, chalk and heavy particles of the kind will be deposited." If it be a chalk water, the calcium carbonate will carry down suspended sewage or vegetable matter, effecting a change of colour. Under such circumstances, the sense of smell may afford confirmatory evidence.

Silicious particles, as of flint or sand, are usually angular; and though often much rounded by rolling and attrition, a vitreous-looking fracture will be observable in many of them, as shown in Plate I. Fig. 4, *a*. It should be mentioned here that a little source of fallacy may be occasioned by the very frequent detachment of minute scales or chips from the margins of the covering glass, or, as before mentioned, the extremity of the pipette, when not properly ground, or even from the glass stoppers of bottles in which specimens are kept. On carefully inspecting the more minute particles of silicious matter, which are so easily diffused and suspended in water, their thin or scale-like character will be apparent. Particles of chalk, clay and marl, on the other hand, are usually more rounded, but the former will be at once recognized by their solubility in acids, with the evolution of carbonic-acid bubbles. The crystalline forms of numerous substances are frequently visible in the smallest molecules. Indeed, the study of the inorganic matters in the sediments of fresh water is a kind of microscopical mineralogy which is of growing interest and importance to the water analyst. It would of course include goniometry, spectrum analysis, and the behaviour of definite particles amongst others, under the action of reagents. In the latter connection, besides the effect of adding a little mineral acid, a useful micro-chemical experiment is to introduce a solution of the mixed prussiates of potash beneath the covering glass, when any ferruginous matter present will be indicated by the blue colour produced.

Nessler's fluid, used in the same way, will often show the presence of organic sources of ammonia, even in an amorphous state. Organic substances, such as the bodies of infusoria, &c., are darkly discoloured by the permanganate of potassium; and by boiling the sediment with solution of the chloride of gold, interesting results may be obtained under the microscope. Altogether there would appear to be great promise in the kind of research here indicated.

SECTION II.

DEAD, OR DECAYING ORGANIC MATTER.

ANY of the forms described in the succeeding section, as living plants and animals, may be found in the sediment of drinking water, either whole or fragmentary, in a dead and more or less decayed state. Their recognition will, in many cases, be difficult, in consequence of the accumulation of débris of different kinds about them, as well as their own altered condition; but when the more unyielding structures remain intact, a little practice, with the help of figures, will enable the observer to determine them with sufficient accuracy for all practical purposes.

A.—*Dead Vegetable Matter.* (Plates II. & III.)

When the higher plants die down, those of a more humble kind seem to flourish with greater vigour, so that however shapeless the decaying masses may be, minute *Oscillatorians*, *Bacteria*, and their allies will usually be found in their vicinity. The breaking down of vegetable cells is of course attended with the discharge of the contained sap, endochrome, &c.; and these will soon assume an amorphous, or irregular granular appearance, in which the original green colour is here and there very evident. Its further change, however, is usually into an olivaceous, or yellowish-brown tint. In some instances, the albuminous inner coat of the vegetable cells, known as the primordial utricle, is seen much contracted within the cellulose coat, passing into an indigo-purple tint in a more advanced stage of decay. With a little care the collapsed and crumpled cell-walls may be recognized casually. But very characteristic of decaying vegetable matter, if it appertain to vascular plants, is the occurrence of spiral vessels, or even the spiral fibres drawn out of the cells; annular ducts, dotted and pitted tissue and hairs, which, from their comparative indestructibility, are sometimes very beautifully dissected out, as it were, by maceration. These at once afford a clue to the nature of the amorphous matter in connection with which they are found.

The little scales of "bog moss" (*Sphagnum*) with their porous or fenestrated cells, the discs and roots of "duckweed" (*Lemna*), sprays of "pond-weed" (*Potamogeton*), or of the "stone worts" (*Chara* and *Nitella*), and segments of the numerous filamentous Algæ may be met with, more or less altered in colour, or otherwise.

Amongst the vegetable products (Plate III.) not properly belonging to the fresh water, but rather indicating contamination from house refuse, may be mentioned the fibres of fabrics, such as linen (1), hemp (2), cotton (3), and the discoidal tissue of ordinary deal or pine (4), swept from the floor. It may be mentioned, in passing, that this well-marked structural particular is assumed to be characteristic of coniferous woods as a whole.

B. *Dead Animal Matter.* (Plates IV. & V.)

Decaying animal, as well as vegetable, matter may consist of materials proper to the fresh water, or foreign to it. To the first class belong, in particular, the dead bodies of *Entomostraca* (water-fleas, &c.), and the numerous forms of segmented or *annulose* animals, including the water-bears and mites, the larvæ of aquatic insects, and the *Annelida* (Naïads and leeches). The *Naïads* are often only to be recognized by their indestructible setæ and ventral hooklets, which may ultimately become quite isolated in the field. Animal products not proper to fresh water may embrace the bodies or exuviæ of terrestrial insects, house-flies and others, often overgrown with *Achlya*[*] and numerous other matters, such as are represented in Plate V., to which the following references will apply:— 1. Fibres of silk; 2. Wool; 3. Human hair; 4. Hair of rabbit —*a.* the shaft, and *b.* the extremity—5. Epithelium from the mouth or mucous surfaces; 6. Ditto from the cutaneous surface; 7. Striped muscular fibre; 8. A feather; 9. Portions of the same more highly magnified; 10. Scales of Lepidoptera. The scales of moths and butterflies are usually flat, with fine longitudinal fluting and a serrated extremity. Hairs, properly so-called, have commonly a soft central axis of cells, often absorbed so as to form a medullary cavity. Wool, on the other hand, is much smaller than hair, as a rule; more compact in the centre, while the superficial imbrication of the component cells is more open and clearly marked. Nucleated epithelial scales are broad and flat, and much more easily recognized than the non-nucleated, and much smaller epithelium from the skin. The nucleus is oval, highly refringent, and it is usually surrounded with minute scattered points spreading towards the margin of the scale. They resist maceration for a considerable time, and thus frequently percolate with other impurities, from latrines into wells culpably sunk in the immediate neighbourhood. It may not be out of place here to call the attention of the observer to the possible presence of the ova of Entozoa in the water under examination. All spherical and ovoid bodies with albuminous-looking and segmented contents should be looked upon with suspicion, until their real nature is determined; accurate measurements of them should be taken, and drawings, if possible, for future recognition. (See Plate XXIII. Figs. 10–14.)

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[*] A colourless parasite, more like a fungus than a siphonaceous plant, which it is supposed to be, on account of its flagellate zoospores. (Plate IX. Fig. 5.)

SECTION III.

LIVING FORMS.

THE simplest grades of plants and animals, or the Protophyta and Protozoa, possess so many characters in common, that it is by no means easy for the uninitiated to determine the true nature or position of numerous minute organisms which constantly present themselves in the field of the microscope. The most reliable means of distinguishing them is founded upon physiological grounds, and more especially their mode of nutrition. For it is quite admitted that no structural particulars can be named, in the abstract, as characterizing the one more than the other. Of course, where the life history of any form has been satisfactorily traced out, the determination must be certain; as, for example, when a zoospore, furnished with motile organs or flagella, is found not only to have originated from a bonâ-fide plant, but ultimately to grow into one itself. Of such organisms, either losing the motile organs spoken of at an early stage of their existence, or retaining them as a permanent character, the *Flagellata* of authors mainly if not altogether consists, forming up to the present time, an order of *Infusoria*. To the casual observer, the equivocal movements executed by the forms of doubtful position are more striking than their intimate structure, while the other parts of their history are quite out of the question. Indeed, in many cases a claim to belong to the animal kingdom has been raised alone upon the exhibition of animal-like movements. The liability to error is therefore all on one side, and as far as we know, not a single genuine protozoon has yet been classed by the botanist in his domain; while our greatest difficulty at the present time is to eliminate the protophyta from the realm of zoology. It will be scarcely doubted that the numerous species of *Difflugia Arcella* and *Euglypha,* for example, are veritable animals; but the equally numerous naked *Amœbæ* are so wonderfully imitated both in appearance and movement by truly vegetable Amœboids, that falling into error in relation to them might be very excusable.

The following kinds of movement may be noticed and compared in the two kingdoms:—

			Protophyta.	*Protozoa.*
Movement.	Without special organs		BACILLUS, &c.	GREGARINA.
	With special organs	By pseudopodia	Amœboids of VOLVOX	AMŒBA.
		By cilia	Spores of VAUCHERIA	PARAMECIUM.
		By flagella	EUGLENA, &c.	NOCTILUCA.

The pliant *Vibrio* and the rigid *Diatom* exhibit the phenomenon of spontaneous movement, connected probably with the play of the same, or similar nutritive processes, developing dialytic currents which are on this account quite invisible, while they operate as a moving cause or movable bodies. In this way the diatom moves without change of form, and shall we say that by the same law the extensile plasma of *Amœba* and Amœboid alike is drawn out into *Pseudopodia,* with the semblance of active and even voluntary motion?

Above the lowest grades of plants and animals, or such as are notified in the above table, no difficulty can arise in assigning to every form its true position; and when the *Flagellata,* as a whole, are placed with the *Protophyta,* as in the following arrangement, nearly all the uncertainty and misunderstanding at present existing will be at once removed.

A. *Living Plants.*

COMPRISING THE MORE USUAL AQUATIC ALGÆ OCCURRING IN THE EXAMINATION OF DRINKING WATER.

Though our knowledge of the fresh-water Algæ has become greatly extended of late years, we are still only in possession of fragmentary particulars in relation to many of the more humble forms; and until the whole life history of each has been satisfactorily traced out, it would be quite impossible to group them so as to be altogether free from objection. The classification here adopted cannot, therefore, purport to be perfect, but it is hoped that it may serve as a guide to the leading characters of the vegetable products usually presented to the observer in the microscopical examination of drinking water.

All observation and experience of late years would go to show that the *Flagellata*, as before intimated, should no longer be classed with the *Protozoa*, but, even pending the possible elimination of any special forms, be at once removed to the *Protophyta*.

The fresh-water Algæ are so diversified in form and character that it would be much easier to point out the particulars in which they differ than to group them in accordance with their natural affinities. On surveying them as a whole, however, some will be seen to preserve the cell form and character more or less distinctly, while others are rod-like, or filamentous, jointed, or tubular. It so happens, perhaps, as a something more than a mere coincidence, that all the families admit of a very similar distribution in these two sections, and may be thus arranged :

ORDER I.—ROD-LIKE OR FILAMENTOUS ALGÆ.

GROUP I.—*Filaments without articulation, free or embedded in a gelatinous frond; Spores simple, minute.*

Distinctive Characters.		*Families.*
(*a*) Without distinct segmentation of the endochrome; exhibiting very active movements.	Microscopically minute, punctiform, elongated, rod-like or filamentous, straight or spiral	BACTERIACEÆ.
(*b*) With regular segmentation of the endochrome, exhibiting spontaneous movements.	Straight, solitary or in bundles, or more or less curved in a gelatinous stratum. .	OSCILLATORIACEÆ.

GROUP II.—*Filaments distinctly articulated; Spores simple or flagellate.*

Distinctive Characters.			*Families.*
(*a*) Moniliform, cleavage sometimes longitudinal.		Simple or forked and contorted in a gelatinous stratum	NOSTOCHACEÆ.
		With rich and ornamental endochrome	ZYGNEMACEÆ.
(*b*) Terete, all cleavage transverse.	Trunks&branches of nearly equal size.	Cells cleaving in the middle without persistent rings .	CONFERVACEÆ.
		Cleavage at the upper or distal end of special cells, with persistent rings	EDOGONIACEÆ.
	Branches smaller than the trunks, ends acuminately produced.	Branching alternately. . .	CHÆTOPHORACEÆ.
		Branches whorled, plain or moniliform	BATRACHOSPERMACEÆ.

GROUP III.—*Filaments tubular, continuous, only sparsely branched; Spores ciliated.*

SIPHONACEÆ.

ORDER II.—CELLÆFORM ALGÆ.

GROUP I.—*Component cells flagellate (equivalent to the Flagellata of authors).*

Distinctive Characters.	*Families.*
(*a*) Integument not distinguishable from the body substance	MONADACEÆ.
(*b*) Integument not only distinct but striated and contractile	EUGLENACEÆ.
(*c*) Integument more or less rigid and non-contractile . .	THECAMONADACEÆ.
(*d*) Cell sheathed in a bipartite carapace, with an intervening ciliated sulcus	PERIDINIACEÆ.
(*e*) Outer envelope urceolate, cells separate or definitely aggregated	DINOBRYONACEÆ.
(*f*) Outer envelope wanting; cells united by their base . .	ANTHOPHYSACEÆ.
(*g*) Outer envelope gelatinous; cells separate or definitely united	VOLVOCACEÆ.

GROUP II.—*Component cells non-flagellate, but fissiparous and conjugating.*

Distinctive Characters.	*Families.*
(*a*) Cells plain, with a gelatinous investment; plane of fission indefinite	PALMELLACEÆ.
(*b*) Cells or frustules ornamented with rich green endochrome; fission definite, margins plain	DESMIDIACEÆ.
(*c*) Frustules silicious, with amber endochrome, fission definite, with overlapping margins	DIATOMACEÆ.

GROUP III.—*Component cells non-flagellate, simple or gemmiparous, with green or colourless contents.*

Cells usually fixed capsular, tubular, straight or curved, and discharging zoospores by rupture or dehiscence .	APIOCYSTACEÆ.

Definition of the foregoing Families, and the Characters of their more important Genera.

ORDER I. — ROD-LIKE OR FILAMENTOUS ALGÆ.

FAMILY I.—*Bacteriaceæ.* (Plates VI. & VII.)

Under the head of *Bacteria,* Cohn has included all the very minute spherical, elongated, dumb-bell shaped, chopped-hair and rod-like, straight and spiral filamentous plants endowed with more or less active spontaneous motion, and now found to be associated with putrefactive and other conditions of hygienic importance. The annexed table, applicable to Plate IV., is in accordance with Dr. Cohn's classification, which he admits must be only provisional, until something more definite is known of the nature and affinities of these interesting organisms. Though the species are not separately described, it was considered advisable to retain them in the table to facilitate further reference, should such be found necessary.

The three first genera—viz., *Micrococcus, Bacterium,* and *Bacillus,* are sufficiently defined; but a few remarks on the distinguishing features of the three remaining genera—viz., *Vibrio, Spirillum,* and *Spirochæta,* might be added in further elucidation of the table. In the passive state, *Vibrio* is nearly straight, slightly flexuous, or obscurely spiral, while *Spirillum* and *Spirochæta* are perfectly spiral; but when in motion *Vibrio* exhibits only a progressive lateral flexure or undulation, while *Spirillum,* though rigid, in itself progresses by rotation on its long axis, just as a corkscrew enters a cork, and lastly, *Spirochæta* combines lateral flexure with rotation.

Clathrocystis æruginosa is a plant of doubtful position, consisting primarily of green cells embedded in a solid gelatinous matrix or frond, but after a while, by rapid development of the cells, the interior becomes hollow; finally, after the separation of certain bud-like projections, a fenestrated body remains. Cohn has lately placed it with *Bacteria,* near *Clathrocystis roseo-persicina,* a plant which forms purplish-red films on decaying algæ along the American coast, but which in Europe is also found in fresh water. In Germany, where it is known as the "Wasserblüthe," it has been destructive to fish, but there is no record of its having any injurious effect upon the human system (Farlow).

Bacteria (Cohn.) (*See* Plate VI.)

		GENUS AND SPECIES.
A. SPHÆROBACTERIA		*Micrococcus.*
(Minute jostling spherules).	Zymogenous. (Ferment producing.)	(*c*) crepusculum (Ehr.)
		candidus (Cohn)
	,,	(*d*) ureæ (Cohn) The ferment of ammoniacal putrescence.
	Chromogenous. (Colour producing.)	(*a*) prodigiosus (Ehr.) The blood stain in bread.
	,,	luteus (Schrœter)
	,,	aurantiacus (Sch.)
	,,	chlorinus (Sch.)
	,,	cyanus (Sch.)
	,,	violaceus (Sch.)
	Pathogenous. (Disease producing.)	(*b*) vaccinæ (Cohn)
		diphthericus (Dartnel)
	,,	septicus (Klebs)
	,,	bombycis (Béchamp)

			Genus and Species.
B. Microbacteria			*Bacterium.*
		(*f, g, h, k*)	termo (Ehr.) Producing putrefactive fermentation.
		(*i, l*)	lineola (Ehr.) In brooks, &c.
	Chromogenous.		xanthium
	„		syncyanum
	„		æruginosum
C. Desmobacteria (Straight, flexible or rapidly undulating filaments.)			*Bacillus.*
		(*n*)	subtilis (Ehr.) Producing butyric fermentation.
		(*m*)	ulna (Cohn) Similar to the former.
			anthracis (Cohn) In the blood, in malignant pustule.
D. Spirobacteria (Spiral filaments, rigid or flexible.)	Movement lateral, undulatory		*Vibrio.*
		(*o*)	rugula (Ehr.)
		(*p*)	serpens (Ehr.)
	„ rotatory, spiral		*Spirillum.*
		(*q*)	tenue (Ehr.)
		(*r*)	undula (Cohn)
		(*s*)	volutans (Ehr.)
	„ both lateral and rotatory		*Spirochæta.*
		(*t*)	plicatilis (Ehr.)

While there is little doubt of the intimate relationship existing between the larger forms of the preceding table and the Oscillatorians, *Bacterium termo* and its immediate allies are involved in much obscurity as to their real nature, and botanical affinities, seeing that their supposed position in the animal kingdom is now no longer tenable. The slightly dumb-bell shape of the true putrefactive (*Bacterium*) manifests a very significant correspondence with the form represented in Plate XXIV., developed in the sediment of well water, and with many others, such as that shown in Plate VII., occurring amongst decomposing Algæ.

All analogy would go to indicate that the *Zooglœa* form of *Bacterium termo* may be regarded as the primary or normal state of this organism, the surrounding gelatinous matter being simply the representative of that which forms the indefinite frond of *Microhaloa* or *Palmella* for example.

Further, when the matrix breaks down, and the separate little *Bacteria* detach themselves from it, they often commence those active movements which are in some intimate way connected with their nutrition. Even many *Diatomaceæ* which are normally fixed to, or included in, a gelatinous frond, are motionless until they have become free from it, when the movements they exhibit are known to bear a certain relation to the shape of the frustule, being rectilinear, when the latter is narrow, as in *Navicula*, but more irregular when it is of a different form. The subsequent history of *Bacteria* has been variously represented by authors. The carbon of the higher aquatic plant is derived from the carbonic acid present in the water, or liberated by the decomposition of carbonates, while that of the molecular and more filamentous Algæ (*Micrococcus*, *Bacterium*, &c.), is usually derived from the vegetable acids that may be in combination with a base, as for example, the $\bar{T}$ of Tartrate of Ammonia.

Dr. Cohn's researches go to show, that not only will *Bacteria* flourish in solutions of the salt just mentioned, or in the absence of organic matter, but that even in this case the genuine putrefactive odour is evolved. Indeed, it may be said that the putrefaction of animal and vegetable matter cannot take place without *Bacteria*, while simple decay is more especially associated with fungous life.

Family II.—*Oscillatoriaceæ*. (Plate VIII.)

These very simple plants consist of cylindrical or tapering filaments, with or without a gelatinous investment, and having faint or rich bluish-green, or purple-coloured contents, or endochrome, in which, as the filaments elongate, a transverse segmentation takes place, giving rise to the deceptive appearance of true articulation or cells in linear series. The filaments may be quite free, or disposed in bundles or strata. In the free state, their peculiar animal-like movements render them objects of interest to the microscopist. Branching, in the true sense of the term, is quite foreign to these plants, which, like the *Bacteria*, multiply by transverse fission; but their sexual reproduction has been only imperfectly made out. They are divided into several sub-families, which are easily distinguished in the manner shown in the following table, with illustrative genera:—

Classification of the Oscillatoriaceæ.

		Distinguishing Characters.		*Sub-families.*		*Genus.*
Frond or filament.	Cylindrical.	Exhibiting more or less active movement		*Oscillatorieæ*		(1.) OSCILLATORIA.
		Motionless .	Like Oscillatoria, but in tufts or strata. . . .	*Lyngbyeæ*		(3.) LYNGBYA.
			Having a proper gelatinous investment . .	*Scytonemeæ*	Invested singly .	(4.) SCYTONEMA.
					Invested in bundles .	(2.) MICROCOLEUS.
	Tapering, with a large basal cell			*Rivularieæ*		(5.) RIVULARIA.

It is highly probable that many of the supposed members of the *Oscillatoriaceæ* are truly referable to the succeeding family (*Nostochaceæ*).

On carefully inspecting a fair specimen of water rich in Algæ of different kinds, it will usually be easy to trace examples of *Oscillatorians* ranging from the proportions of ordinary *Confervæ* to the diameter of *Bacteria*. The same phenomena of spontaneous movement and endochrome cleavage may be observed when the filaments are free in the field, whether normally so or liberated from their gelatinous investment. Moreover, any differences distinguishable in the smaller, as compared with the larger forms, can only be said to be of a relative kind, and apparently in no way contra-indicate a prevailing unity of type. Frequently also the smaller moving points or molecules observable in the field, instead of being referable to the genus *Micrococcus*, are but segments of the more minute filamentary species or varieties, as the case may be; for, even if their cylindrical form is not demonstrable to the eye, their peculiar refractive properties will enable us to link them with the less equivocal fragments always to be found in the same vicinity.

In the punctiform, fragmentary, on filamentous plants of smaller size than the admitted Oscillatorians, it would be impossible to distinguish a primordial utricle and a cellulose coat, and of course, also difficult to determine the precise nature of the segmentation should such really take place. In the *Oscillatoriæ*, however, the endochrome alone is supposed to suffer cleavage, while the primordial utricle and the cellulose tube take no part in the process, being only capable of simple growth and extension. In the *Confervaceæ* and the other filamentous Algæ, on the contrary, both the primordial utricle and the endochrome are engaged in the segmentation of the filament within the cellulose coat, to which, nevertheless, the transverse septa and new internal layers are added.

In a very interesting paper published in the *Quarterly Journal of Microscopical Science*, vol i. 1861, Dr. B. Hicks, F.R.S., describes a lateral expansion by cleavage in *Lyngbya muralis*, thus showing it to be dimorphous, and allusion is made to the extremely small size of its gonidia. The plant in question, though confounded by some with the genuine *Confervæ*, is now generally admitted to be an ally of the *Oscillatorians*, and as such at least one of its modes of development or transitional phases presents a suggestive bearing upon all the members of this family, and thereby, it may be fairly presumed, upon *Bacteria* in general.

We thus perceive how slender are the grounds upon which we can assume almost any palmellaceous plant, for example, to be a distinct entity, and in this remark may be included some forms reputedly belonging to the *Ulvaceæ.* Let us suppose for a moment the minute *Spirilla* and even *Bacterium termo* itself to be in the category of the filamentous Algæ, then how small must be their reproductive gonidia. From actual observation, the writer must say that the moving particles in which the Spirillum common in bilge-water originates, however small they may have been in the first instance, are not only very minute, but quite shapeless. In the light of this fact, we may again submit the question, if the corresponding particles are visibly so small in relation to the diameter of *Lyngbya muralis,* how small must be their original state in the case of *Bacterium termo.* They might readily escape the keenest scrutiny of the advocates of equivocal generation.

The *Oscillatoriaceæ* are ubiquitous as a family, though many of them are very definitely distributed; thus the *Rivulariæ* appear to be confined to northern regions; they are often found on the stumps of aquatic plants, on rocks in rapid streams, and sometimes where they are exposed to the force of cataracts. They frequently also indicate calcareous water, and crystals of carbonate of lime may be deposited in their substance. A pretty little species presents the appearance of minute green stars upon the surface of lakes. In India *Oscillatorians* ascend to 17,000–18,000 feet above the level of the sea.

FAMILY III.—*Nostochaceæ.* (Plate VIII.)

Plants consisting of microscopic moniliform filaments of cells in series, usually coiled, curved, or entangled in a gelatinous matrix constituting the frond, which may be rounded, foliaceous, linear, or formless. They are found in damp places, or in water, floating on the top, or at the bottom attached to stones in rivulets and streams, or in brackish ditches. The characters of the frond afford the readiest means of distinguishing the three more important genera, thus—

Frond	elongated, curved, linear or spiral;	filaments	single .	Monormia.
„	expanded, globular or irregular;	„	numerous	Nostoc.
„	formless, often a floating film;	„	„	Trichormus.

Besides simple multiplication by fission (which is sometimes longitudinal as well as transverse, reminding one of *Lyngbya* in this respect), the *Nostochaceæ* afford indications of the existence of a true reproductive system, in the presence of certain vesicular cells (supposed to be spermatic ?) amongst the ordinary ones; which latter are, moreover, here and there further developed into sporangial cells, producing true spores from which new filaments arise. This process appears to have been distinctly observed by Thuret in *Nostoc verrucosum.*

In reference, more particularly, to the *Oscillatoriaceæ* and *Nostochaceæ,* Dr. Farlow, Assistant Professor of Botany in the Harvard University, has published some very interesting remarks in the Bulletin of the Bussey Institution, Jan. 1877. Having failed to obtain any precise information as to the cause of a cucumber taste often noticed in the Boston water supply at the fall of the year, he speaks of odours as affording more definite indications. Of these, three kinds are especially mentioned—viz., 1. "An indescribably suffocating odour, as in the case of several *Lyngbyæ* and *Oscillatoriæ.* 2. "A sulphurous odour" given off by species of *Beggiatoa.* 3. "A still more disagreeable odour," resembling that of a "pig-pen or very strong horse-dung," arising from species of *Nostoc* in a decaying state. "The chemical nature of the stifling odour is not known," nor is it peculiar to nostocs or even to fresh-water plants. "It is marked in several marine plants, as *Polysiphonia fastigiata,* which forms blackish tufts on the larger rock weed."

"The Algæ which exhale sulphurous odours belong to the genus *Beggiatoa,* which resembles *Oscillatoriæ,* in consisting of filaments endowed with motion, but which differ in colour, being whitish, the cells being full of opaque granules. They look to the naked eye like white films covering decaying Algæ and other plants. They are found on the sea-shore, as well as in fresh water, but are particularly common in hot springs. Cohn has shown that the peculiar exhalations of hot sulphur springs are owing to the growth of species of *Beggiatoa*, which depend for their existence upon, at least, two conditions; the presence of a large amount of sulphur in the water, and the absence of iron. Cohn confirms the observation of Cramer, that the dark granules in the species of *Beggiatoa* consist of sulphur. When *Beggiatoa* filaments are heated, the granules fuse into large yellowish drops, and a sulphurous odour is developed. If the filaments are treated with sulphide of carbon, the granules are dissolved, and then the cell partitions become, for the first time, visible." Dr. Farlow goes on to describe a new species of *Plectonema* (of the Order *Nostochineæ*). The *Plectonema Wollei* (*Farlow*) "is a summer plant, and does not attain considerable dimensions before July. It starts on the stems, leaves and old sticks on the bottom, and forms coils several feet in length. On reaching the surface it expands over considerable areas. In the latter part of September it breaks away from its attachments, drifts ashore, and disappears, to return next summer."

Masses of slimy matter with decaying cell-chains, of some species of *Nostochacious* plant, supposed to belong to the genus *Anabæna*, were found on the margin of the water, or entangled in the meshes of the above-mentioned *Plectonema;* and it was noteworthy that while the decaying *Anabæna* gave out the odour of rotting horse-dung, the living *Plectonema*, free from the slime, emitted the suffocating smell of many of the *Oscillatorians*, but not the pig-pen odour. This latter odour, however, was developed in decaying *Plectonema*, proved to be free from

Anabæna by microscopical observation. Details of this description are just what we want, to afford us reliable data for hygienic deduction and consequent good counsel.

FAMILY IV.—*Zygnemaceæ.* (Plate IX.)

Plants consisting of cylindrical articulated filaments with green contents, usually disposed in elegant patterns. Reproduction is effected by the phenomenon of conjugation, the whole contents of each pair of united cells being converted into a spore. The particulars of the manner in which this process takes place will be seen in the definitions of the following genera:—

Classification of the Zygnemaceæ.

	Distinguishing Characters.			*Genera.*
Conjugating.	By transverse tubes between the neighbouring cells of different filaments	Spores formed in one of the parent cells.	Endochrome spiral.	(1.) SPIROGYRA.
			Endochrome in two round or stellate masses	(2.) ZYGNEMA.
		Spores formed in the connecting tubes.	Endochrome in two round or stellate masses	(3.) ZYGOGONIUM. .
			Spores rounded, endochrome diffused.	(4.) MESOCARPUS.
	By an arcuate tube between neighbouring cells of the same filament.	Spores formed in one of the parent cells.	Spores square or cruciate, endochrome diffused .	(5.) STAUROCARPUS.
			Spores ovoid, endochrome spiral . .	(6.) RHYNCHONEMA.
		Spores formed in the connecting tube.	Endochrome diffused	(7.) PLEUROCARPUS.

The *Zygnemaceæ* are found in rivers and running waters. In India, amongst the Himalayas, they reach a height of 15,000 feet.

FAMILY V.—*Confervaceæ.* (Plate X.)

Plants composed of cylindrical cells forming articulated filaments, simple or branched, with a very delicate gelatinous coat. The cell contents are usually green, rarely brown or purple, often assuming peculiar patterns, and ultimately converted into zoospores, with two or four flagella, from which the filamentous fronds are reproduced.

From a fresh-water point of view, only three genera appear to be of importance—viz., *Cladophora*, *Rhizoclonium*, and *Conferva;* and even these may all be yet included in the succeeding family.

All the species with branching filaments may be referred to the genus *Cladophora;* for though many species of *Rhizoclonium* have root-like branches, it so happens that those found in fresh water have simple filaments, which are best distinguished by their decumbent habit from the simple filaments of *Conferva.*

Cladophora glomerata occurs in dark green wavy skeins in pure running water, and *C. crispata* (*b*) in yellowish or dull green strata, commonly in fresh though frequently also in brackish water.

Renzoclonium rivulare is found in fine, bright, green bundles, 2–3 feet long, in streams and rivers, while *R. implexum* occurs on mountain rocks.

Conferva bombycina, in which the cells are four or five times as long as they are broad, is met with as a yellowish green cloudy stratum in stagnant water, while *C. floccosa* (*a*) with cells once or twice longer than broad, with circumcissile dehiscence, is to be found everywhere in pools and still waters.

The *Confervaceæ* and *Zygnemaceæ* flourish in similar situations, as a rule, but the habitat of the *Confervaceæ* is more varied.

FAMILY VI.—*Œdogoniaceæ.* (Plate X.)

Articulated filamentous plants, simple or branched, exhibiting much variety in their means of reproduction. Thus the whole contents of a cell produce zoospores with a rich growth of cilia, and sporangial cells develop large resting spores; while antheridial structures are present either on the ordinary filaments, or on dwarf parasitic plants. The filaments grow by a rather peculiar process, commencing with circumcissile division of the cellulose coat of the interstitial cells, which thus permits of the growth or extensions of the primordial utricle, or under-coat, and the formation of a new septum. A cementing band of cellulose repairs the gap between the divided borders of the parent cell, leaving an annular impression to record the fact, and the repetition of the process produces a repetition of the rings, which always characterize even fragments of these plants.

The two genera are easily distinguished, the filaments of *Œdogonium* (*c*) being simple, and those of *Bulbochæte* (*d*) branched, and bearing bristle-cells with a bulbous base.

The species of *Œdogonium* abound in fresh water under almost all conditions, in lakes, ponds, pools, ditches, streams, and in tanks and cisterns. *Bulbochæte setigera* (*d*), apparently the only reliable species of the genus, grows luxuriantly upon other fresh-water plants.

FAMILY VII.—*Chætophoraceæ.* (Plate X.)

These are very beautiful, branched and articulated plants enveloped in gelatinous matter, and made up of cells in single series. Some are free, with a straight central axis; while others are fixed with depressed radiating branches, or forming a discoidal frond. The tapering extremities of the branches, in some instances, are quite bristle-like, affording one of the distinctive characters of the family. Bristles of an inarticulate kind, however, arise from the articulations in certain genera. Finally, spores and four-ciliated zoospores are formed from the contents of the cells.

Draparnaldia presents a central axis of large colourless cells, with tufts of smaller branches at the articulations. In *Chæto-phora* (*c*) the filaments are branched and setigerous, indefinitely embedded in gelatinous matter. In *Coleochæte* the frond is discoidal and adherent, composed of radiating dichotomously branched filaments, and the bristles springing from the back of the joints are sheathed at the base.

FAMILY VIII.—*Batrachospermaceæ.*

These plants are evidently very closely allied to the *Chætopheraceæ,* and the name is derived from the resemblance which their beaded filaments bear to frog's spawn. The central axis consists of a single series of cells, with an investment of expressed filaments descending from joints or nodes, occurring at stated intervals, and also giving rise to dense whorls of exceedingly delicate moniliform branches. Some of these latter produce spores at their extremities, whilst others form transparent capillary points. The spores are agglomerated at the nodes.

In *Batrachospermum,* the ramuli are moniliform, while in *Thorea* they are cylindrical. These plants are exclusively aquatic, but chiefly found in pure and gently running water, like the *Chætophoraceæ.*

The *Lemaniaceæ* are usually noticed near the *Batrachosperms* in systematic works, though differing much both intrinsically and in external appearance. They are olive-coloured, tubular and branched filamentous plants, distinguished from the *Siphonaceæ,* presently to be described, in the compound cellular structure of the tube wall, instead of being simple, and the sprouting of tufted whorls of spores in moniliform series from its inner surface. The genus *Lemania* is represented by two British species, *L. torulosa* and *L. fluviatilis,* and from their natural habit their presence would indicate running water.

FAMILY IX.—*Siphonaceæ.* (Plate IX.)

The tubular, simple, or branched frond of the *Siphonaceæ* are composed of a continuous extension of cellulose lined with green endochrome granules, and the reproductive elements are formed within special outgrowths of the tubular membrane.

Excluding such members of the family as are purely marine, only two fresh-water genera are worthy of notice here—viz., *Vaucheria* and *Achlya* (*Saprolegnia*, Kützing).

Vaucheria (1 to 4). Most of the species of this genus are inhabitants of fresh water, though they are also to be found in moist, or even in merely damp, localities, as in the clay of flower-pots intermixed with moss. They are frequently to be seen on the borders of roadside streamlets, with their branched tubular filaments almost felted together in fine, silky green tufts. The little granules of chlorophyle in the interior of the filaments are for the most part applied to the walls, embedded in a colourless protoplasm. Zoospores are formed in the club-shaped ends of the filaments. Unger observed that these bodies usually made their escape about eight o'clock A.M., at which time the process may be observed in healthy plants, cultivated in fresh water. A true sexual mode of reproduction also exists in *Vaucheria*, and the spores are richly ciliated. Of the numerous species of this genus that have been described, it would appear that only two or three are reliable.

Achlya prolifera is a small colourless plant, consisting of clavate erect tubular filaments springing from a mycelium-like minutely ramified base, closely applied to the bodies of dead flies in water, fish and frogs, upon which they grow parasitically. It was originally supposed to be the common fly fungus, or an aquatic form of *Botrytis Bassiana*, but more recent researches, rewarded by the discovery of ciliated zoospores, and a perfect sexual system like that of *Vaucheria,* have given the plant what would appear to be an uncertain position. Apropos of the want of colour in this parasitic form, it will be noticed that *Chytridium* and *Pythium,* which are parasitic members of the *Apiocystaceæ,* are also without colour.

The *Siphonaceæ* (Vaucheria, for example) are often found in large tufts on mud, whether impregnated with salt or fresh water. *Codium amphibiorum* in particular flourishes on turf banks at high water, while other members of the family are altogether marine.

Though the *Characeæ* are not generally admitted to belong to the Algæ properly so called, as they are likely to be met with in samples of water, it may be well to give a short account of the family here. In these interesting plants, while the vegetative apparatus is of a very simple type, the generative system is more highly developed than in any of the preceding forms. The plants consist of a number of large tube-like cells, forming a central axis, and whorls of similar, but smaller, cells at the nodal points. So far, this description will answer the genus *Nitella,* which may attain a length of several inches; but in *Chara* an additional envelope is furnished to the central stem by closely applied tubular cells passing from the nodes in both directions, and meeting at the middle of the internodes.

The antheridia and germ cells are here respectively named *globules* and *nucules.* Eight triangular valves radially fluted, and numerous confervoid filaments with antherozoids in the cells, make up the globule; while fine spirally-twisted tubes form the investment of the nucule. So short a notice of those organs is only given to facilitate their recognition when detached.

The *Ulvaceæ* are plants composed of a single or double layer of polyhedral cells, multiplying by fission, disposed in tabular or tubular frondose extensions, chiefly marine, but in some few instances occurring in brackish or fresh water.

The long tubular fronds of *Enteromorpha intestinalis* are sometimes found in fresh-water ditches, but more usually in brackish or salt water.

ORDER II.—CELLÆFORM ALGÆ.

GROUP I.—*Flagellate Forms, or Flagellata.*

FAMILY I.—*Monadaceæ.* (Plate XI.)

				Distinguishing Characters.	*Genera.*
Without distinct integument.	With one filament.	Without cilia.	Mobile throughout.	General form, and beak rounded	(1.) MONAS.
				Beak turned to one side	(2.) PLEUROMONAS.
				Beak abruptly truncated	(3.) CYATHOMONAS.
				Beak produced flagellum at its base	(4.) CHILOMONAS.
			Mobile at the extremity		(5.) CYCLIDIUM.
		With cilia also (Parasitic)			(6.) TRICHOMONAS.
	With two filaments.			Similar, at the curved angles	(7.) TREPOMONAS.
				One on each side in front	(8.) AMPHIMONAS.
				One posterior	(9.) CERCOMONAS.
				One trailing	(10.) HETERAMITA.
	With six filaments, four in front and two behind				(11.) HEXAMITA.

Habitat, &c.—The Monads, so called, are especially found in decaying organic infusions animal and vegetable, in or beneath the pellicle or scum, usually forming on the surface under such conditions. *Trepomonas, Amphimonas* and *Hexamita* are to be seen in marsh-water undergoing change. *Cercomonas intestinalis* has been detected in the dejections of typhoid and cholera, and *Trichomonas vaginalis* in vaginal mucus. *T. limacis* is found in the intestine of *Limax agrestis,* a common slug.

FAMILY II.—*Euglenaceæ.* (Plate XI.)

		Distinguishing Characters.			*Genera.*
Integument distinct, striated, contractile.	Attached				(1.) COLACIUM.
	Free.	No visible flagellum, two eye spots			(2.) DISTIGMA.
		One flagellum	With an eye	with a tail	(3.) EUGLENA.
				without a tail	(4.) AMBLYOPHIS.
			No eye spot, flagellum	rigid at the base	(5.) PERANEMA.
				mobile to the base	(6.) ASTASIA.
		Two flagella	An eye spot, green or red		(7.) CHLOROGONIUM.
			No eye spot, colourless		(8.) ZYGOSELMIS.
		Several flagella			(9.) POLYSELMIS.

Habitat, &c.—The members of this family are often seen in immense numbers, at the surface of pools and ponds, imparting a rich green colour to the water. Like many if not all the *Monadaceæ,* they are only developmental phases of forms distinguished by other names. *Colacium* is a parasitic genus and of an exceptionally bright green colour. It is not quite clear whether the little currents produced by it are due to the action of vibratile cilia or a flagellum. *Colacium vesiculosum* and *C. stentorium* are found on *Entomostraca* and *Rotifera.* Of the true nature of *Distigma* but little is known; green, yellow and colourless species have been described, all aquatic. Their movements are more leech-like than those of *Euglena,* but there are just as few grounds for referring them to the animal kingdom. *Euglena viridis* moves from place to place by the contractile power of its integument, as well as by the flagellum, which is sometimes absent.

Amblyophis is rather like *Euglena,* but its posterior extremity is rounded, while that of *Euglena* is acuminate. *Peranema* much resembles *Astasia,* but the flagellum is stout and only mobile at the tip in the former, while it is mobile throughout in the latter. *Chlorogonium enchlorum* is either solitary or united in radiating groups like little fishes united by their tails, a resemblance which is much heightened by the position of the eye spot.

It is common, like *Glenodinium*, of which it is a further stage of development in standing pools and shallow waters; and when we are told that it is itself but one phase of *Protococcus*, whose zoospores constitute the so-called genus *Chlamidomonas* (the green matter of Priestly), and that other genera rightly or otherwise are referable to the same source, whatever that may be, we see how artificial and uncertain all attempts at a natural classification of these forms must be in the present state of our knowledge. For hygienic purposes, however, the recognition of each in the abstract will suffice with the knowledge of its habitat to enable us to form a judgment of the medium in which it lives, or more practically the properties of the water in which it is detected. *Zygoselmis* is at once distinguished from *Polyselmis* by the absence of colour and having only two flagella in continual movement. *Polyselmis* is supposed to be merely the zoospore of an Algæ.

FAMILY III.—*Thecamonadaceæ.* (Plate XI.)

Distinguishing Characters.				*Genera.*
Integument distinct, hard or fibrous.	With one flagellum.	Form, globular, integument.	Hard encasing .	(1.) **TRACHELOMONAS.**
			Membranous .	(2.) **CRYPTOMONAS.**
		Form, depressed foliaceous.	With a tail . .	(3.) **PHACUS.**
			Without a tail.	(4.) **CRUMENULA.**
	With two flagella, one trailing			(5.) **ANISONEMA.**

Habitat, &c.—The integument of *Trachelomonas* is hard and even brittle; indeed the genus should probably be rather classed with *Chætoglena* and *Chætotyphla* than with *Phacus, &c.* By transmitted light in *T. volvocina* a red ring is seen to surround the cell contents. *Phacus* and *Crumenula* differ from *Euglena* and *Amblyophis* in having a rigid integument, and it may be mentioned to aid the memory that *Phacus* and *Euglena* represent one another by having a tail-like process, while the posterior end is rounded off in both *Crumenula* and *Amblyophis.*

In *Cryptomonas* the integument is flexible, but the species are ill defined. *Anisonema* is colourless like the monad *Heteromita,* from which it would only appear to differ in the consistency of the external covering. Through a small aperture in this coat the flagella of *A. sulcata* are transmitted. The trailing filament would seem to act as a steer-oar, but it also serves to retract the body under an impulse which it is difficult to comprehend.

The remaining genera, *Diselmis, Plœotia* and *Oxyrrhis,* are marine.

FAMILY IV.—*Peridiniaceæ.** (Plate XII.)

Distinguishing Characters.			*Genera.*
With a stout carapace, simple or divided into two parts by a ciliated groove.	Undivided setaceous.	With an eye spot .	(1.) CHÆTOGLENA.
		No eye spot . . .	(2.) CHÆTOTYPHLA.
	With a ciliated furrow.	With an eye spot .	(3.) GLENODINIUM.
		No eye spot . . .	(4.) PERIDINIUM.

Habitat, &c.—*Chætoglena* and *Chætotyphla* are supposed to be the spores of *Algæ,* and as the absorption band of chlorophyll in the case of *Peridinium fuscum* has been satisfactorily demonstrated by Mr. Angel, of Southampton, there may be still less scruple in referring the genus to the domain of the botanist.

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* For the practical purpose of this work the above classification has been retained, though the following is a more modern arrangement, after M. de Fromentel:

With a stout carapace divided into two parts with interposed cilia.	With a transverse groove.	Two halves of the carapace nearly equal.	With horn-like processes . .	CERATIUM.
			Without horn-like processes . .	PERDINIUM.
		Two halves of the carapace very unequal.	Borders projecting	DINOPHYSIS.
			Borders not projecting . . .	AMPHIDINIUM.
	Ciliated at the anterior border			PROBOCENTRUM.

Marine forms are of course also included here.

P. cinctum is an aquatic form, but said never to be present in decomposing water, from which circumstance one would say that its occurrence would not augur badly.

FAMILY V.—*Dinobryaceæ.* (Plate XII.)

Distinguishing Characters.			*Genera.*
With urceolate outer envelope.	Cells solitary. Sessile		(1.) EPIPYXIS.
	Cells in communities.	In close series simple, or sparsely branched . . .	(2.) DINOBRYON.
		On distinct foot-stalks . .	(3.) STYLOBRION.
		Grouped together at the summit of a single stem .	(4.) PYCNOBRYON.

Habitat, &c.—*Epipyxis* always wants the eye spot and often the flagellum, while both eye spot and flagellum are persistent in *Dinobryon.* To these two genera M. de Fromentel has added two others—viz., *Stylobryon* and *Pycnobryon,* but nothing is mentioned as to their habitat. The better-known genera are aquatic, and generally to be found with other algæ in a living state.

FAMILY VI.—*Anthophysaceæ.* (Plate XII.)

In communities without a common envelope.	In spherical clusters, united inferiorly.	Fixed at the extremities of a branched axis	(1.) ANTHOPHYSA.
		Swimming freely	(2.) UVELLA.
	United by their sides		(3.) TETRABÆNA.

Habitat, &c.—M. de Fromentel includes this and the former family in his *Volvocina,* which it is perfectly allowable to subdivide even for the convenience of description. The branched tubular axis of *Anthophysa* is often found with other vegetable débris in pond, bog, and marsh water, and the detached flagellate bodies resemble the genus *Uvella* very closely both in appearance and movement. *Uvella uva* especially is a suspicious species.

FAMILY VII.—*Volvocaceæ*. (Plate XII.)

- In communities with a gelatinous envelope.
  - Envelope single.
    - United by stolons.
      - In square tatelets . (1.) GONIUM.
      - In spherical extensions . . . . . (2.) VOLVOX.
      - At the centre of this gelatinous mass . (3.) PANDORINA.
    - Disseminated in the mass . . . (4.) ALLODORINA.
  - Envelope double . . . . (5.) DIPLODORINA.

Transitional form PROTOCOCCUS (6).

Habitat, &c.—The *Volvocaceæ* occur in ponds and sheets of clear water on commons and in bog-pools. *Uroglena syncrypta, Sphærosira,* and *Synura* are very doubtful genera. In *Pandorina* the flagellate bodies are united by their base and centrally disposed in the mass; while in *Volvox* they are placed peripherally. In *Allodorina* these bodies are independently distributed in the connecting substance, without any special organic union. *Gonium pectorale,* which is not uncommon in fresh-water pools, is also found in salt water, in both cases near the surface. *G. glaucum* is more particularly a salt-water species.

The life history of the genus *Protococcus,* so far as it has been traced out by Cohn and others, though presenting a variety of conditions and stages, shows a close relationship to the cells of the *Volvocaceæ.* In one of its developmental phases a motile cell encysted after a fashion, breaks up into four by cleavage, but frequently these remain united by their beaked extremity, the segmentation remaining incomplete. This is, however, quite the reverse of what normally takes place in the case of *Volvox.* The Volvox sphere results from the segmentation of a single mass of endochrome, the ultimate subdivisions of which assume the flagellate motile character, and become organically united by the mutual blending of little stolon-like processes, piercing the hyaline investments, which are hexagonal by contact with each other, and lateral compression. A similar union also takes place in the cells of *Gonium*, and in those of *Pandorina*, which occupy the centre of the gelatinous frond. Thus while the connection of the four motile cells of *Protococcus* arises from incomplete cleavage, the communication existing between the cells of *Volvox* and *Gonium* is sequential to complete cleavage.

The union of primarily distinct elements to constitute what must be called the perfect organism is further seen in a representative way in the *Pediastreæ*, which are generally admitted to be a sub-family of *Desmidiaceæ*, and in the remarkable genus *Hydrodictyon*, supposed to be siphonaceous.

GROUP II.—CELLS NON-FLAGELLATE, BUT FISSIPAROUS AND CONJUGATING.

FAMILY I.—*Palmellaceæ*. (Plate XIII.)

Green cells (though sometimes red), spherical or ovate, in a more or less consistent or definitely formed gelatinous frond; the cell multiplying by simple fission, without gemmation.

Of the numerous genera referred to this family, the following may be taken as good examples:—

Classification of Palmellaceæ.

Frond.	Indefinite or formless.	Mucoid, *floating*, with minute cells .	(1.) MICROHALOA.
		Slimy, *encrusting*, with large globular cells	(2.) PALMELLA.
	More consistent and definite in form.	Globular, including numerous distinct cells	(3.) COCCOCHLORIS.
		Band-like, simple or branched, with cells in twos or fours in single series	(4.) HORMOSPORA.

Though the precise limits of the *Palmellaceæ* are yet but imperfectly defined, these plants are of considerable interest to the water analyst, they so frequently find their way into cisterns and reservoirs, and thus make their appearance in the deposits of drinking water. Several genera would appear to be more correctly referable to the *Volvocaceæ* or other families, and the accumulation of synonyms has only added to the confusion.

To illustrate multiplication by fission in the *Palmellaceæ*, the genus *Coccochloris* may be instanced; this will enable us to see what little more is required to meet the conditions observable in the *Desmidiaceæ* and *Diatomaceæ* respectively. In *Coccochloris* (3 *a* and *b*) binary subdivision, with the successive formation of a cellulose and hyaline investment, seems to go on practically without limit, a fresh impetus to the process being given by the conjugation and blending of two endochromes (*c*), in which repeated fission goes forward as before. This is, in effect, also what takes place in the *Desmids* and *Diatoms*, and the observation is so far correct, even though *Coccochloris* and its allies should be, as some suppose, but the gonidia of lichens in a certain phase of development.

These plants are often found under comparatively dry conditions, as on the weather side of trees, or on old walls, forming a greenish efflorescence, in which case the gelatinous coat is much reduced in bulk. On the return of moisture, however, it will swell up again, and in a constant drip it assumes a glairy appearance.

FAMILY II.—*Desmidiaceæ*. (Plates XIII. & XV.)

These are unicellular plants, usually of an exceedingly rich green colour, nearly exclusively confined to fresh water, occurring singly, or remaining in contact after binary subdivision, so as to form more or less brittle threads or cells in linear series.

A sutural line running round the cell wall transversely, marks it off into two symmetrical halves, and cleavage takes place at this line, preparatory to the gemmation of two new half frustules from the old ones thus separated. The forms of these cells are very beautiful and varied, and chiefly characterize the genera, which admit of the following arrangement:—

Classification of the Desmidiaceæ.

1. Cells separate.	Plain and much elongated—*Closterieæ*	Curved or crescentic			1. CLOSTERIUM.
		Straight	Ends rounded	Contents simple	2. PENIUM.
				Contents spiral	3. SPIROTÆNIA.
			Ends truncated		4. DOCIDIUM.
			Ends notched		5. TETMEMORUS.
	Ornamental, short, or of moderate length—*Cosmarieæ*	Deeply incised			6. MICRASTERIAS.
		Sinuated			7. EUASTRUM.
		Simple	Without spines		8. COSMARIUM.
			With two spines		9. ARTHRODESMUS.
			With several spines		10. XANTHIDIUM.
		End view angular	Projections single		11. STRAURASTRUM.
			Projections double		12. DIDYMOCLADON.
2. Cells forming filaments.	*Desmidieæ*	Cells oppositely bidentate	Filaments rounded		13. DIDYMOPRIUM.
			Filaments angular		14. DESMIDIUM.
		Cells deeply constricted	Junction glandular		15. SPHEROZOSMA.
		Cells slightly constricted	Junction simple		16. HYALOTHECA.
			Junction perforate		17. APTOGONUM.
3. Cells in bundles, or loosely aggregated.	*Ankistrodesmieæ*				18. & 19. SCENEDESMUS.
					20. ANKISTRODESMUS.
4. Cells after cleavage, recombining to form a compound frond.	*Pediastrieæ* (Plate XV.)	Frond	Discoidal		21. PEDIASTRUM.
			Spherical		22. CŒLASTRUM.
			Reticulated		23. HYDRODICTYON.*

In *Pediastrum* (Plate XV.) the form originates in the cleavage of an endochrome into two, then four, and finally some multiple of this, when a radial frondose expansion is formed by the subsequent juxtaposition, and union of the cells in some definite and characteristic manner. In *Hydrodictyon,* on the other hand, a motile cell breaks up into numerous distinct endochromes, which acquire a cellulose coat, and so arrange themselves as to form a reticulation of minute cylindrical cells, which gradually increase in size, and finally attain the character and dimensions of the perfect plant. *Hydrodictyon* would therefore appear to hold a relationship to *Pediastrum* and *Cœlastrum*, similar to that which *Volvox* bears to *Gonium* or *Pandorina;* the latter organisms being made up of motile, and the former of ordinary vegetable cells.

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* Only placed here provisionally.

FAMILY III.—*Diatomaceœ.* (Plate XIV.)

Like the former family, the *Diatomaceœ* are unicellular plants, in some instances isolated, in others cohering in chains of filaments, or in some definite way. The cell wall, however, is composed of a glassy or silicious material, instead of cellulose, which is found in all other vegetable cells ; and the endochrome is usually of a rich amber tint instead of green. They exhibit also much symmetry and beauty in the forms of the frustules, which are often so exquisitely sculptured as to afford excellent test objects for the microscope.

Each frustule consists of a new and an old half or valve, as noticed in the *Desmidiaceœ,* but the margins of the old valve overlap those of the new one, and thus results the so-called cingulum or "middle piece," which is not only capable of elongation by growth, but also by one portion sliding upon the other, telescope fashion, so as to make provision for the endogenous development of two new half frustules by fission and gemmation combined. From this arrangement it follows that the cells of each successive generation must be narrower than those within which they arise, by at least the whole thickness of the cell wall. Here, then, is the explanation of the great disparity of size so frequently observed in members of the same species. Moreover, we thus also see why it is that after the conjugation of two frustules, the resulting sporangial cell, in which the process just described commences, should be so much larger than the parent cell.

The genera of *Diatomaceœ* are too numerous to be separately defined in this treatise ; but the annexed table, with the figures arranged in the same order, will assist in the recognition of the more usual fresh water forms :—

Division 1. Not immersed or enveloped in a gelatinous frond.	Tribe 1. *Striatæ*. With linear sculpturing.	Without a median nodule.	*Eunotieæ*	Arcuate	Without terminal nodules		1. EPITHEMIA.
					With terminal nodules.	Separate	2. EUNOTIA.
						In a filament	3. HIMANTIDIUM.
			Meridioneæ.	Cuneate		In a close spiral band	4. MERIDION.
			Fragilarieæ.	Quadrilateral.	Striæ granular	A close chain	5. FRAGILARIA.
					Striæ continuous.	Single	6. DENTICULA.
						In a close chain	7. ODONTIDIUM.
					Striæ scarcely visible.	In a zigzag chain	8. DIATOMA.
						In a star-like chain	9. ASTERIONELLA.
			Melosireæ	Discoidal		Mostly single	10. CYCLOTELLA.
				Cylindrical, or globose		In a filament	11. MELOSIRA.
			Surirelleæ	Subquadrate, ovate, or elliptical, with marginal furrows		Saddle-shaped	12. CAMPYLODISCUS.
						Full border, simple	13. SURIRELLA.
						Depressed, borders undulate	14. SPHINCTOCYSTIS.
				Much elongated		Compressed, with median puncta	15. NITZSCHIA.
						Prismatic, with a pseudo-nodule	16. SYNEDRA.
		With a median nodule.	*Cocconeideæ*.	Elliptical		Fixed by one surface	17. COCCONEIS.
			Achnantheæ.	Bent		With a stalk	18. ACHNANTHES.
						Without a stalk	19. ACHNANTHIDIUM.
			Cymbelleæ	Inequilateral, not sigmoid		Without a stalk	20. CYMBELLA.
						With a stalk	21. COCCONEMA.
			Gomphonemeæ	Wedge-shaped		With a stalk	22. GOMPHONEMA.
			Naviculeæ	Ends full & rounded		Striæ continuous	23. PINNULARIA.
				Ends more acute	Straight	Striæ dotted, without a stauros	24. NAVICULA.
						With a stauros, or transverse bar	25. STAURONEIS.
					Sigmoid	Striæ in both directions	26. GYROSIGMA.
				Ovoid, inflated			27. AMPHORA.
	Tr. 2. *Vittatæ*. With infoldings of the wall of the frustule.		*Striatelleæ*	Quadrilateral	Vittæ Simple but interrupted.	A close series	28. TETRACYCLUS.
						A zigzag chain	29. TABELLARIA.
					Vittæ Capitate, like notes in music		30. TERPSINOE.
Division 2. Immersed, or enveloped in a gelatinous frond.			*Mastogloieæ*	Like *Navicula*.	Hoops with loculi	Frond mammillated	31. MASTOGLOIA.
					Hoops simple	Frond amorphous	32. FRUSTULIA.
						Frond filamentous	33. COLLETONEMA.
				Like *Cymbella*		Frond filamentous	34. ENCYONEMA.

GROUP III.—CELLS NON-FLAGELLATE, SIMPLE OR GEMMIPAROUS, WITH GREEN OR COLOURLESS CONTENTS.

FAMILY I.—*Apiocystaceœ.* (Plate XV.)

The members of this family seem to be grouped with the *Palmellaceœ* as a matter of convenience. They are, however, quite distinct in their habit and relations. The fronds are composed of single cells, usually fixed at one end, and the reproductive elements are developed in the same cells, apparently engaging the whole contents.

The following genera may be met with amongst other *Algœ* :—

Plants	Non-parasitic with green contents . .	Dehiscence irregular, slit-like	Pyriform, with gonidia in fours, forming numerous zoospores . .	(1.) APIOCYSTIS.
			Fusiform, with a parietal starch granule and green contents, forming zoospores . . .	(2.) HYDROCYTIUM.
		Dehiscence subterminal circumcissile	Cylindrical, curved, with 8 gonidia, which are dispersed when ripe .	(3.) OPHIOCYTIUM.
			Cylindrical, straight, with 8 gonidia forming an umbel, like the parent cell, at its extremity	(4.) SCIADIUM.
	Parasitic on Confervoids, with colourless contents . . .		Globose, with a lid, growing upon cells, and sending their pedicle inwards . . .	(5.) CHYTRIDIUM.
			Flask-shaped, growing within cells and piercing the walls to discharge their gonidia	(6.) PYTHIUM.

B. *Living Animals.*

The smaller, or microscopic Fauna of the fresh water, as might be expected, is rather comprehensive, including representatives of all the sub-kingdoms and many of the classes of Invertebrata. This will be seen at a glance in the annexed Table, the arrangement of which will be followed in the succeeding pages :—

A General Table of Classification of Animal Forms, with short Explanatory Notes embodied.

Sub-Kingdom.	*Division.*	*Class.*	*Sub-Class.*	*Section.*	*Order.*	*Genus.*
I. PROTOZOA (The first, or simplest forms of animal life.)		1. *Rhizopoda* (Like the contents of a cell, throwing out and retracting root-like variable extensions of the body, named pseudopodia.)			(*a*) Radiolaria (Pseudopodia radiate.)	ACTINOPHRYS.
					(*b*) Reticularia (Ps. reticulate.)	GROMIA.
					(*c*) Lobosa (Ps. lobed or digitate.)	AMŒBA.
					(*d*) Spongida (Sponges.)	SPONGILLA.
		2. *Infusoria* (Cell-like, with locomotive cilia.)			Ciliata (With cilia.	PARAMECIUM.
II. CŒLENTERATA (Stomach and body-cavity in communication = Polypes.)		*Hydrozoa* (Polypes of the Hydra type.)			(*a*) Hydrida (Hydra-like.)	HYDRA.
					(*b*) Corynida (Coryne-like.)	CORDYLOPHORA.
III. ANNULOIDA (Like Annulosa.)		*Scolecida* (Worms.)			(*a*) Turbellaria (Ciliated worms.)	PLANARIA.
					(*b*) Nematoda (Smooth thread-worms.)	ANGUILLULA.
					(*c*) Rotifera (Wheel animalcules.)	ROTIFERA.
IV. ANNULOSA (Ringed or segmented.)	A. ANARTHROPODA. (Limbs absent or inarticulate.)	*Annelida* (Body ringed.)			(*a*) Hirudinea (Leeches.)	GLOSSIPHONIA.
					(*b*) Oligochæta (Few bristled.)	NAIS.

- IV. ANNULOSA (Ringed or segmented.) (*Continued.*)
  - B. Arthropoda (With articulated limbs—Articulata.)
    - 1. *Crustacea* (Shell coated = crabs, lobsters, and their allies.)
      - A. *Entomostraca* (Literally, shelled insects.)
        - 1. *Lophyropoda* (Stiff hair-footed.)
          - (*a*) Ostracoda (With bivalve shells.) . . . . Cypris.
          - (*b*) Copepoda (Oar-footed.) . . . . Cyclops.
        - 2. *Branchiopoda* (Gill-footed.)
          - (*a*) Cladocera (Branch-horned.) . . . . Daphnia.
          - (*b*) Phyllopoda (Leaf-footed.) . . . Branchipus.
      - B. *Malacostraca* (Soft-shelled, as compared with the testaceous mollusca.)
        - *Edriophthalmata* (With sessile eyes.)
          - (*a*) Isopoda (Equal footed.) . . . . Asellus.
          - (*b*) Amphipoda (Feet turned different ways.) . . . Gammarus.
    - 2. *Arachnida* (Spiders and their allies.)
      - A. *Trachearia* (Breathing by the general surface, or trachea.)
        - (*a*) Tardigrada (Water bears.) . . . Macrobiotus.
        - (*b*) Acarina (Water mites.) . . . . Hydrachna.
    - 3. *Insecta* (Six-legged articulata = Insects properly so called.)
      - (*a*) Coleoptera (Beetles.) . . . Dytiscus.
      - (*b*) Hemiptera (Bugs.) . . . Notonecta.
      - (*c*) Trichoptera (Caddice flies.) . . . Phryganea.
      - (*d*) Neuroptera (Dragon flies.) . . . Libellula.
      - (*e*) Diptera (Gnats, &c.) . . . . Culex.
      - (*f*) Aptera (Wingless.) . . . . . Atax.
- V. MOLLUSCA (Soft bodied.)
  - A. Molluscoida (Like Mollusca.)
    - *Polyzoa* (Numerous by budding, with ciliated tentacula.)
      - (*a*) Hippocrepia (Horseshoe-shaped.) . . . Cristatella.
      - (*b*) Infundibulata (Funnel-shaped.) . . Paludicella.
  - B. Mollusca (Proper) = shell-fish.
    - 1. *Lamellabranchiata* (Bivalve, with two-fold gills.)
      - (*a*) Asiphonida (Without respiratory siphons.) . . . Unio.
      - (*b*) Siphonida (With respiratory siphons.) . . . . Cyclas.
    - 2. *Gasteropoda* (Univalve, with a creeping disc.)
      - (*a*) Prosobranchiata (Gill in front of the heart.) . Paludina.
      - (*b*) Pulmonifera (With a breathing chamber.) . . . Planorbis.

To facilitate the recognition of objects under examination, the definitions given of the five sub-kingdoms of invertebrate animals should be carefully studied, after which it will be found comparatively easy to refer each organism to its proper position in the Table—noting that the definitions apply more particularly to the fresh-water forms.

I. The *Protozoa* (Siebold) are small or minute bodies, more or less partaking of the character of simple cells, furnished with vibratile cilia (for locomotion, or the development of currents in the water); or resembling merely the contents of cells, without integument, but capable of throwing out mobile extensions of the "sarcode," or gelatinous substance of the body. The members of this latter class are named *Rhizopoda*, from the root-like forms of the locomotive processes, while those of the former, in accordance with the arrangement adopted in this work, constitute the ciliated portion of the *Infusoria* proper, or the *Ciliata* of authors.

II. The *Cœlenterata* (Frey and Leuckart) are distinguished by having the lining membrane of the stomach continuous with that of the body cavity. The single class *Hydrozoa* is represented by the *Fresh-water Polypes.*

III. The *Annuloida* (Huxley) embrace all the worm-like animals which are not true *Annelida* and the wheel animalcules. Thus, in the preceding Table, the class *Scolecida* (σκώληξ, a worm) includes the ciliated Flatworms (*Turbellaria*), the Threadworms (*Nematoda*), and the Rotifers (*Rotifera*).

IV. The *Annulosa* are distinctly ringed, or segmented animals. They may be divided into three groups—viz. (*a*), *Apoda*, without feet or *Leeches;* (*b*) *Anarthropoda*, with inarticulate limbs; other *Annelida*, and (*c*) *Arthropoda* having articulated limbs. The latter are still further divided into *Crustacea,* with a variable number of limbs, but typically seven pairs, *Arachnida,* or spiders with four, and *Insecta,* with three pairs of legs.

V. The *Mollusca,* as the name implies, are soft-bodied animals, usually protected by a crustaceous covering or shell. They are divided into an inferior class (*Molluscoida*) taking in the *Limniades* or fresh-water *Polyzoa,* and a superior one (*Mollusca* proper), represented by the fresh-water snails and mussels, or shellfish so-called.

As all the classes have been named and sufficiently characterized in the foregoing definitions, attention may next be directed to the orders and the illustrative, or more usual genera given in the general Table of Classification with short definitions of the technical terms employed.

I. PROTOZOA.

I. *Rhizopoda.* (Plate XVI.)

Besides the *sponges,* which are represented by the genus *Spongilla* (found in still or slowly running waters, on stones, old woodwork, &c.), the *Rhizopoda* admit of distribution into three groups, easily distinguishable by the characters of the *pseudopodia,* or the motile extensions of the body substance already noticed. In the first group or order (*a*) (*Radiolaria*) they are slender and raylike, persistent, or slowly retractile. In the second (*b*) (*Reticularia*) they are firmly branched, more or less intercommunicating, or reticulate; while in the third (*c*) (*Lobosa*) they are lobose or digitate. These orders will be better understood on inspecting the following synopsis of the genera. They have the advantage, at least, of being simple, though of course they can only be provisional in the present state of our knowledge of the subject.

(a) *Radiolaria.*

Pseudopodia delicate ray-like simple, besetting the spherical surface.

Body	Naked.		(1.)	ACTINOPHRYS.
	With a covering or shell	With fine spiculæ; free . .	(2.)	ACANTHOCYSTIS.
		Fenestrated; with a pedicle	(3.)	CLATHRULINA.

Habitat.—Actinophrys digitata amongst marsh plants; *A. Eichornii* on the surface of infusions, and with *A. discus* (*Trichodiscus*) and the other species, amongst confervæ and aquatic plants. *Acanthocystis, and Clathrulina* occur in bog-water.

(b) *Reticularia.*

Pseudopodia filiform, reticulate, or finely branched; localized; body, globose or ovoid.

Pseudopodia	Closely reticulated; sarcode reflected over the shell . .		(1.)	GROMIA.
	Finely branched in a bunch	At one end	(2)	PLEUROPHRYS.
		At both ends	(3.)	AMPHITREMA.

Habitat.—Gromia fluviatilis on *Ceratophyllum, G. hyalina* (with a short neck) in rivulets. *Pleurophrys* and *Amphitrema* in bog-water.

(c) *Lobosa.*

Pseudopodia lobose or digitate, simple or dividing.

Body	With a shell	Pseudopodia, fine and simple, shell flask-shaped.	Two or three; subterminal	(1.)	TRINEMA.
			Numerous; terminal . . .	(2.) & (3.)	EUGLYPHA.
		Pseudopodia, stout and dividing	Shell flask-like	(4.)	DIFFLUGIA.
			Shell discoidal	(5.)	ARCELLA.
		Pseudopodium single . . .	Shell subcubical	(6.)	CYPHIDIUM.
	Naked . .	Pseudopodia, variable		(7.)	AMŒBA.

Habitat.—*Trinema acinus* and *Euglypha tuberculata* in stagnant water; *Difflugia proteiformis* and *oblonga* amongst *Oscillatoriaceæ;* numerous other species in moist moss at the roots of trees; *Arcella vulgaris* with *Lemnæ* and aquatic plants *A. aculeata* and *A. dentata* with *Confervæ; Cyphidium aureolum* in stagnant water; *Amœba diffluens* on *Lemna* and *A. radiosa* in bog-water.

(d) *Spongida.* (Plate IV.)

Spongilla, the only fresh-water genus, occurs in little grey or greenish more or less rigid or friable masses, with a spicular framework. They present a superficial or dermal coat, numerous inhalant pores, internal ciliated chambers, and an exhalant aperture. Their grey or green colour is due to the amount of chlorophyll taken into the sarcode or soft substance of the sponge. The silicious spicules which are often present in the sediment of fresh water are—1, birotate; 2, short crescentic, and echinate; or 3, in the form of stout needles rounded at one end and acute at the other.

2. *Ciliata.* (*Infusoria.*) (Plates XVII. & XVIII.)

Excluding the *Flagellata,* the *Infusoria* proper will only consist of the *Ciliata* of authors, or the ciliated animalcules, which are furnished with a mouth (*Stomatoda*), but in other respects exhibit a very rudimentary organization. Here it may be remarked that, as the object of this work is to facilitate the recognition of the forms themselves, it has not been considered necessary to follow any more modern arrangement of the *Ciliata.* The objectionable points of Dujardin's system are sufficiently known to the well informed, and they can be of little moment to those who can only give a small share of attention to the subject.

The *Ciliata* then, as the name implies, are furnished with vibratile cilia, variously distributed either as connected with the mouth or the general surface; and those organs exhibit a great variety of character. Thus we have the terms *setæ*, *cirri*, *hooks*, and *styles*, to express some of their modifications; their uses may be said to be threefold—viz.:

1. For the production of currents in the water, the purveyors of food, and fresh air.
2. For locomotion, swimming, walking, or jumping.
3. For resistance, offence or defence.

These animalcules are generally very voracious, notwithstanding the simplicity of their organizations; and it is noteworthy in a hygienic sense that if the water in which they are found is deficient in organic matter available for food, either from its actual purity, or from the thorough decay of what may have been originally present, the transparency and leanness of their bodies, and the restlessness of their search for aliment will show that they are in a half-starved condition. Solitary *Vorticellæ* are often the only ciliata to be seen in what may be termed exhausted water, or that in which the organic matter is so far destroyed as to leave no assimilable food for other forms. In some waters of this class even *bacteria* may be observed to drag out an inactive existence. The notable presence of the *Ciliata*, however, would indicate not only stagnant water, but such as may contain organic matter in solution to some relative extent not yet precisely determinable.

General Table of the Ciliata.

Characters.				*Families and Illustrative Genera.*
1. Integument non-contractile.	Naked	No apparent mouth, cilia scattered		ENCHELIA. (*Enchelys; Alyscum.*)
		Mouth with an oblique or circular row of cilia,	Without cirri	TRICHODINA. (*Trichoda; Trachelius.*)
			With cirri also	KERONIA. (*Kerona; Halteria.*)
	With a carapace (diffluent)			EUPLOTA. (*Euplotes; Hymantophorus.*)
2. Integument with serially disposed cilia.	Free	No oral fringe		PARAMECIA. (*Paramecium; Glaucoma.*)
		With an oral fringe		BURSARINA. (*Bursaria; Leucophrys.*)
	Fixed	Voluntarily		URCEOLARINA. (*Urceolaria; Stentor.*)
		By special organs		VORTICELLINA. (*Vorticella; Epistylis.*)

(a.) *Euchelia.—Duj.* (Plate XVII.)

Body	Partially ciliated.	Cilia at one end	(1.) ACOMIA.
		Cilia in a longitudinal furrow	(2.) GASTROCHÆTA.
	Ciliated all over.	Cilia all alike	(3.) ENCHELYS.
		With retractile filaments also	(4.) ALYSCUM.

Further description and habitat.—1. *Acomia vitrea,* ovoid minute (length 1–868″), occurring in decomposing infusions and water of a corresponding description.

2. *Gastrochæta fissa,* ovoid, colourless, convex dorsally, ending abruptly in front, and in a blunt tubercle behind, length 1–400″, found in stagnant water.

3. *Enchelys nodulosa,* Duj., *Pantotrichum Enchelys* of Ehr. Other species of *Enchelys* Duj. are confounded with the genus *Cyclidium,* Hill, and to add to the confusion Dujardin applies this latter term to a genus of *Flagellata.* (See *Monadaceæ.*) *E. nodulosa* is usually found on the borders of decaying matter in stagnant water, movements sluggish.

4. *Alyscum saltans*, length 1–1260″, much resembles the last species in general appearance, though longer and possessed of a trailing filament, which is therefore characteristic, as well as retractile cilia, by which a jerking movement is effected. In river water kept for some time, and vegetable infusions, this form is frequently to be seen.

(b.) *Trichodina*. (Plate XVII.)

Cilia	Covering the body.	Fore part curved like a hatchet	(1.) PELECIDA.
		Neck long and slender	(2.) DILEPTUS.
		Upper lip forming a proboscis	(3.) TRACHELIUS.
	In front chiefly.	On each side, in opposite directions	(4.) ACINERIA.
		In one row, directed forwards	(5.) TRICHODA.

Further description and habitat.—1. *Pelecida rostrum* of Dujardin, or *Loxodes rostrum* of Ehrenberg, having a noncontractile integument, is thus distinguished from the *Paramecia*.

2. *Dileptus folium*, as its name implies, is leaf-like lanceolate in form, with the mouth at one side of the base of a proboscidiform extension of the body in front. It is richly ciliated, particularly near the mouth.

3. *Trachelius anas* also has a mouth at the base of a trunk-like prolongation; it is distinguished from *Amphileptus* by having a branched intestine. It should be mentioned that Dujardin founded his genus *Dileptus* on those species of *Amphileptus* which do not possess a reticulated integument. Both genera are found in clear running marsh water, and streams amongst aquatic plants and Algæ, and their presence would thus rather indicate living than decaying conditions.

4. *Acineria acuta* exhibits a row of cilia arising from one side and directed forwards. The only other species, *Acineria incurvata*, is marine.

5. *Trichoda angulata* is described as having the body obliquely and irregularly folded or angular.

(c.) *Keronia.* (Plate XVII.)

Form
- Short and rounded, with a row of stout cilia, and fine setæ for jumping . . . . (1.) HALTERIA.
- Oval or elongated.
  - Creeping organs in regular rows . . (2.) OXYTRICHA.
  - Creeping organs not in regular rows.
    - With styles also
      - few, or single behind. . . (3.) UROSTYLA.
      - numerous behind, with frontal cirri also . . . (4.) STYLONYCHIA.
    - Without styles . . . (5.) KERONA.

Further description and habitat.—1. *Halteria grandinella.* This is a small, nearly spherical, animalcule, 1–850″ greatest breadth; it presents an oblique row of stout cilia at the circumference, and very delicate radiating cilia, by which its peculiar jerking movements are effected. Generally found in indifferent water in the neighbourhood of organic débris.

2. *Oxytricha gibba,* length 1–240″. Body lanceolate, convex above and flat below, with a double row of setæ, often in bad water with the former.

3. *Urostyla grandis.* This form is rounded at both ends, a little larger in front than behind, and altogether proportionately more elongated than *Stylonychia,* but without the same armature. Length 1–120″.

4. *Kerona polyporum.* Short as compared with the preceding and following, and slightly reniform. Length 1–144″. (See note on the *Hydrida,* p. 59.)

5. *Stylonychia histrio.* At once distinguished by its numerous styles and the regularity of its outline.

A General Table of Classification of Animal Forms, with short Explanatory Notes embodied.

Sub-Kingdom.	*Division.*	*Class.*	*Sub-Class.*	*Section.*	*Order.*	*Genus.*
I. PROTOZOA (The first, or simplest forms of animal life.)		1. *Rhizopoda* (Like the contents of a cell, throwing out and retracting root-like variable extensions of the body, named pseudopodia.)			(*a*) Radiolaria (Pseudopodia radiate.)	ACTINOPHRYS.
					(*b*) Reticularia (Ps. reticulate.)	GROMIA.
					(*c*) Lobosa (Ps. lobed or digitate.)	AMŒBA.
					(*d*) Spongida (Sponges.)	SPONGILLA.
		2. *Infusoria* (Cell-like, with locomotive cilia.)			Ciliata (With cilia.	PARAMECIUM.
II. CŒLENTERATA (Stomach and body-cavity in communication=Polypes.)		*Hydrozoa* (Polypes of the Hydra type.)			(*a*) Hydrida (Hydra-like.)	HYDRA.
					(*b*) Corynida (Coryne-like.)	CORDYLOPHORA.
III. ANNULOIDA (Like Annulosa.)		*Scolecida* (Worms.)			(*a*) Turbellaria (Ciliated worms.)	PLANARIA.
					(*b*) Nematoda (Smooth thread-worms.)	ANGUILLULA.
					(*c*) Rotifera (Wheel animalcules.)	ROTIFERA.
IV. ANNULOSA (Ringed or segmented.)	A. ANARTHROPODA (Limbs absent or inarticulate.)	*Annelida* (Body ringed.)			(*a*) Hirudinea (Leeches.)	GLOSSIPHONIA.
					(*b*) Oligochæta (Few bristled.)	NAIS.

IV. ANNULOSA (Ringed or segmented.) (*Continued.*)	B. ARTHROPODA (With articulated limbs—Articulata.)	1. *Crustacea* (Shell coated = crabs, lobsters, and their allies.)	A. *Entomostraca* (Literally, shelled insects.)	1. *Lophyropoda* (Stiff hair-footed.)	(*a*) Ostracoda (With bivalve shells.)	CYPRIS.
					(*b*) Copepoda (Oar-footed.)	CYCLOPS.
				2. *Branchiopoda* (Gill-footed.)	(*a*) Cladocera (Branch-horned.)	DAPHNIA.
					(*b*) Phyllopoda (Leaf-footed.)	BRANCHIPUS.
			B. *Malacostraca* (Soft-shelled, as compared with the testaceous mollusca.)	*Edriophthalmata* (With sessile eyes.)	(*a*) Isopoda (Equal footed.)	ASELLUS.
					(*b*) Amphipoda (Feet turned different ways.)	GAMMARUS.
		2. *Arachnida* (Spiders and their allies.)	A. *Trachearia* (Breathing by the general surface, or trachea.)		(*a*) Tardigrada (Water bears.)	MACROBIOTUS.
					(*b*) Acarina (Water mites.)	HYDRACHNA.
		3. *Insecta* (Six-legged articulata = Insects properly so called.)			(*a*) Coleoptera (Beetles.)	DYTISCUS.
					(*b*) Hemiptera (Bugs.)	NOTONECTA.
					(*c*) Trichoptera (Caddice flies.)	PHRYGANEA.
					(*d*) Neuroptera (Dragon flies.)	LIBELLULA.
					(*e*) Diptera (Gnats, &c.)	CULEX.
					(*f*) Aptera (Wingless.)	ATAX.
V. MOLLUSCA (Soft bodied.)	A. MOLLUSCOIDA (Like Mollusca.)	*Polyzoa* (Numerous by budding, with ciliated tentacula.)			(*a*) Hippocrepia (Horseshoe-shaped.)	CRISTATELLA.
					(*b*) Infundibulata (Funnel-shaped.)	PALUDICELLA.
	B. MOLLUSCA (Proper) = shell-fish.	1. *Lamellabranchiata* (Bivalve, with two-fold gills.)			(*a*) Asiphonida (Without respiratory siphons.)	UNIO.
					(*b*) Siphonida (With respiratory siphons.)	CYCLAS.
		2. *Gasteropoda* (Univalve, with a creeping disc.)			(*a*) Prosobranchiata (Gill in front of the heart.)	PALUDINA.
					(*b*) Pulmonifera (With a breathing chamber.)	PLANORBIS.

(f.) *Bursarina.* (Plate XVIII.)

Body.	Urceolate with large oblique mouth, fringed with cirri.	Acuminate behind with an eye spot in front		(1.) OPHRYOGLENA.
		Rounded behind, no eye spot	Cilia within the buccal fossa	(2.) BURSARIA.
			No cilia within the buccal fossa. . . .	(3.) LEUCOPHRYS.
	Linear cylindrical mouth near the middle, within the curled end of a row of cilia			(4.) SPIROSTOMUM.

Further description and habitat.—1. *Ophryoglena acuminata.* Colour, brown; eye spot, red. Two other species are also distinguished by their colour—viz., *O. flavicans,* yellow, but also having a red eye spot; and *O. atra,* black with a black eye spot.

2. *Bursaria vorticella.* So called from its resemblance to a vorticella detached from its stalk. Ehrenberg has described numerous species of this genus, many of which are found in stagnant fresh water.

3. *Leucophrys* (a) *patula* and (b) *spathula.* The length of the former is 1–288″, and of the latter 1–144″. The body of *L. patula* ovate, and full resembling *Bursaria.* It is found in both fresh and salt water; *L. spathula* is more elongated, compressed, and slightly pointed behind;=*spathidium hyalinum,* Duj. and is apparently confined to the fresh water.

4. *Spirostomum ambiguum,* length 1–12″. Covered with cilia and quite colourless, long, narrow and flexible. Some Bursarina are found in the intestine of the frog, and of Nais.

(g.) *Urceolaria.* (Plate XVIII.)

Clustered vorticella-like animals in a gelatinous mass . . .			(1.) OPHRYDIUM.
Solitary.	With a crown of cilia at both ends, body short and discoidal		(2.) URCEOLARIA.
	Crown of cilia in front only.	Body trumpet-shaped, ciliated all over, mouth spiral	(3.) STENTOR.
		Bell-shaped, smooth, tail subulate.	(4.) UROCENTRUM.

Further description and habitat.—1. *Ophrydium versatile.* In this interesting form the common gelatinous substance is quite transparent and colourless, but the little animals, which are 1–100″ in length, are green. The whole mass, which ranges from the size of a pea to some inches in diameter, bears some resemblance to frog's spawn.

2. *Urceolaria pediculus* may be seen gliding over the surface of *Planaria* (see also the note appended to the table of the species of *Hydra,* p. 59).

3. *Stentor cœruleus.* The species of Stentor appear to be all aquatic, and some of them are large and very beautiful objects.

4. *Urocentrum turbo.* Length 1–430 to 1–290″, crown only ciliated, tail one-third the length of the body.

(h.) *Vorticellina.* (Plate XVIII.)

Stalk present.	Bodies all uniform.	Stalk spirally flexible	Simple	(1.) VORTICELLA.
			Branched	(2.) CARCHESIUM.
		Stalk inflexible		(3.) EPISTYLIS.
	Bodies of two shapes.	Stalk inflexible		(4.) OPERCULARIA.
		Stalk spirally flexible		(5.) ZOOTHAMNIUM.

Further description and habitat.—1. *Vorticella microstoma.* Length of body 1–2000 to 1–250″; colour greenish-white, rim narrowed.

2. *Carchesium polypinum.* Length 1–580 to 1–430″; the little peduncles have separate muscles, and the bodies are quite campanulate, with an expanded rim.

3. *Epistylis crassicollis.* The articulations of the pedicles are annular and rather turgid, and the rim, though narrow, is better defined than it is in *V. microstoma.* Numerous species are found on *Entomostraca* and *Algæ.*

4. *Opercularia articulata* and *O. berberina* are found parasitic on water beetles. Following the example of Claparède

and Lachmann, the species of *Opercularia* are now usually referred to *Epistylis.*

5. *Zoothamnium arbuscula.* Length of the bodies 1–430″. The muscle of the trunk ramifies with the branches, so that there is no regular articulation of the latter at their point of origin.

Symmetrical Forms. (Plate XIX.)

The genera (1) *Ichthydium,* (2) *Chætonotus,* (3) *Coleps,* and (4) *Planariola,* are placed by Dujardin in an appendix to the *Ciliata,* though they appear to have no natural affinity *inter se,* on account of exhibiting a bilateral symmetry, which, singularly enough, is wanting in all the other ciliated Infusoria.

II. CŒLENTERATA. (Plate XIX.)

The only *Cœlenterata* occurring in fresh water are members of the sub-class *Hydroida,* the two first Orders of which—viz., *Hydrida* and *Corynida*—are represented by the respective genera *Hydra* and *Cordylophora.*

(a) *Hydrida.*

The first Order is distinguished by the Polypites or separate Zooids being single and locomotive, with a sucker disc at one end, and an oral orifice at the other, surrounded with tentacula. The integument never develops a sclerous layer, and the reproductive organs appear as simple external processes of the body.

Table of the Species of the Genus Hydra.

Body	Cylindrical or insensibly narrowed towards the base.	Tentacula shorter than the body, smaller at the base	(1.)	*H. viridis.* (Leaf green.)
		Tentacula as long as or longer than the body, tapering to the end .	(2.)	*H. vulgaris.* (Yellowish or red.)
	Attenuated below in a marked degree.	Tentacula longer than the body .		*H. attenuata* (Pale olive green.)
		Tentacula several times longer than the body		*H. fusca.* (Brown or greenish.)

Habitat.—In ponds and still waters on *Lemna* and aquatic plants.

Note.—Parasitic Infusoria are often found upon these Polypes—viz., *Kerona polyporum* on *H. vulgaris* and *H. fusca;* and *Urceolaria pediculus* on *H. vulgaris* and *H. viridis.* Their presence, however, would indicate impurity of the water and an unhealthy condition of the Polypes themselves.

(b) *Corynida.*

In this, the second, Order, the Polypites are either single or two or more connected by a common substance or "*Cœnosarc,*" always fixed at the base, and usually developing a firm outer layer or "*Polypary.*" The reproductive organs or "*Gonophores*" arise either from the Polypites, the Cœnosarc, or the so-called "*Gonoblastidia.*"

Genus *Cordylophora* (Allman).

Polypary horny, branched, and rooted by a creeping tubular stolon; polypes ovoid, with a small mouth, and scattered filiform tentacula.

(3.) *Cordylophora lacustris* was the only species known to Allman, but lately a second, *C. rivularis,* has been added.

III. ANNULOIDA.

1. *Scolecida.*

(a) *Turbellaria.* (Plate XIX.)

Non-parasitic ciliated worms. Some of these are bisexual, with a single alimentary or oral opening, and constitute the first sub-order (*Planarida*), including fresh-water species, whilst others are unisexual, with two alimentary openings, and form a second sub-order (*Nemertida*) altogether marine.

Planarida.

				Illustrative Genera.
Intestine	Straight—*Rhabdocœla*	Concatenated		(1.) DEROSTOMUM.
		Single	Mouth near the fore part	(2.) PROSTOMUM.
			Mouth near the middle	(3.) MESOSTOMUM.
	Ramose—*Dendrocœla*			(4.) PLANARIA.*

Habitat:—All in ponds and gently moving deep water amongst aquatic plants.

(b) *Nematoda.* (Plate XX.)

The non-parasitic threadworms composing the family of *Anguillulidæ* are very frequently met with in fresh waters. The vinegar eel (*Anguillula aceti*), and sour paste eel (*A. glutinis*), and the *Tylenchus* (or so-called *vibrio tritici*), invading the ears of corn, belong to this family. *Anguillula fluviatilis* is colourless or white, about fifteen times as long as it is broad, with a fusiform œsophagus, expanding posteriorly into a much larger stomach. 1, Anguillula found in bilge-water; 2, A. aceti; 3, A. fluviatilis.

The *Anguillulæ* are readily confounded with the *Enoplidæ*, a family of minute parasitic *Nematodes*, infesting the intestine of aquatic larvæ and other small animals, but often found free in the water.

(c) *Rotifera.* (Plate XX.)

The Wheel Animalcules, so called on account of the deceptive appearance produced by the regular and consecutive action of the vibratile cilia fringing the head-lobes. These latter may be simple, sinuated, lobed or divided, and are capable of retraction and protrusion. The alimentary system is usually distinct, with a dental apparatus and two orifices, and the sexes are separate.

As a whole these little creatures present superficial points of

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* The hair-worms *Gordius* and *Mermis*, found in moist places and pools, seem to hold the same relation to the true thread-worms that the Planarians do to the Nemertians.

resemblance to the *Entomostraca*, to which the character of their segmentation makes a nearer approach than that of any *Annelida*. Indeed they have been rather appropriately named *Cilio-crustaceans* by Leydig. Dujardin grouped them in the following simple manner:—

	Illustrative Genera.
1. Those that are fixed	*Floscularia. Melicerta.*
2. Those that swim only . . .	*Brachionus. Furcularia. Albertia.*
3. Those that both swim and crawl	*Rotifer.*

Ehrenberg's arrangement, though perhaps more artificial, may still be found more convenient for the recognition of genera.

Rotifera.

Sections.	*Divisions.*	*Families and Illustrative Genera.*
I. *Monotrocha.* Wheel organ simple. . .	1. *Holotrocha.* Margin entire—carapace. . .	Absent—ICHTHYDINA.* Ichthydium podura.
		Present—ŒCISTINA. (1.) Œcistes crystallinus.
	2. *Schizotrocha.* Margin sinuous—carapace . .	Absent—MEGALOTROCHÆA. (2.) Megalotrocha flavicans.
		Present—FLOSCULARLÆA. (4.) Floscularia ornata.
II. *Sorotrocha.* Wheel organ divided . .	1. *Polytrocha.* Into several parts—carapace .	Absent—HYDATINÆA. (5.) Hydatina senta.
		Present—EUCHLANIDOTA. (3.) Monostyla quadridentata.
	2. *Zygotrocha.* Into two parts—carapace . .	Absent—PHILODINÆA. (6.) Rotifer vulgaris.
		Present—BRACHIONÆA. (7.) Brachionus amphiceros.

IV. ANNULOSA.

A. *Anarthropoda.* 1. *Annelida.* (Plate XX.)

(a) *Hirudinea.*

All the Leeches have a more or less sucker-like mouth, and are also furnished with a disk-shaped caudal sucker; and

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* Ichthydium podura and Chætonotus larus will be found amongst the symmetrical Infusoria (Plate XIX., 1 and 2), to which Dujardin has referred them. Their true position, however, has scarcely yet been determined.

although the body is finely annulated, it is divided into larger somites or segments like other Annelida. The nervous system is highly developed, and the sexes are combined in the same individual; but neither self-impregnation nor reproduction by fission or gemmation has been observed in any case. The fresh-water types may be thus arranged:—

			Genera.
Eyes	10 in number	With jaws and teeth, but no proboscis	Hirudo.
	Less than 10	With no teeth or proboscis. . .	(2.) Nephelis and Bdellia.
		With proboscis, but no teeth . .	(3.) Glossiphonia.

Habitat.—In ponds and lakes and slowly-moving waters.

(b) *Oligochæta.* (Plate XX.)

The *Oligochæta* or *Setigera,* include the *Earthworms* (*Lumbricini*) and the true water worms (*Naiadidæ*). Their bodies are usually much elongated, and furnished with locomotive chitinous setæ or bristles attached in rows to the sides and ventral surface laterally. The *Lumbricini* are hermaphrodite, and the *Naididæ* unisexual, but the latter also multiply in a remarkable way by gemmation and fission.

Families.		*Genera.*
1. *Lumbricini.* (Terrestrial and aquatic.)	Having four rows of setæ, two dorsal and two ventral, on each side	Tubifex.
2. *Naiadidæ.* (All aquatic.)	Two rows of setæ, one dorsal and one ventral, on each side; the four first segments without dorsal setæ . , ...	(1.) Nais.
	With ventral setæ only	Chætogaster.

In Lamarck's genus *Stylaria* the setæ are very long, and the cephalic segment is produced into a kind of proboscis. The genus *Proto,* founded by Oken, is distinguished by the presence of ciliated tentaculiform processes surrounding the dorsal and subterminal vent, as in Fig 1 a.

Habitat.—All these little worms live amongst aquatic plants, burrow in the mud, or manufacture little tubes into which they retreat for protection. The *setæ,* but more especially the ventral uncini (1 b), which are usually bifid at the extremity, are frequently found in the sediment of water in which Algæ have been kept for some little time.

Note.—In some instances two speck-like eyes are present, and they may be confounded with the aquatic larvæ of insects. They differ, however, in having the setæ implanted beneath the general surface, and the absence of the fine dark ramifications of the tracheæ and of oral or cephalic organs of any kind, except the above-mentioned eye-specks.

B. *Arthropoda.*

1. *Crustacea.*

A. Entomostraca. (Plate XXI.)

The first four out of the six Orders of Crustacea bearing aquatic genera belong to the sub-class *Entomostraca,* which may be said to consist of an empirical assemblage of usually very small or minute crustaceans, having either less than seven, or more than ten, pairs of legs. To this it must be added, that the branchiæ are either attached to the oral organs, constituting the first section *Lophyropoda,* or to the legs, composing the second section *Branchiopoda.* Each of these is still further divided (as in the general Table) into two Orders.

1. *Lophyropoda.*

(a) *Ostracoda.*

Body completely enclosed in a bivalve carapace or shell. Legs, 2 or 3 pairs.

	Families.		*Genera.*
A single eye.	Cypridæ (Legs, 2 pairs).	Both pairs of antennæ with a tuft of hairs	(1.) CYPRIS.
		Inferior antennæ without the tuft . . .	(2.) CANDONA.
	Cytheridæ (Legs, 3 pairs).	Superior antennæ without the tuft . . .	(3.) CYTHERE.

Habitat.—In ponds and lakes.

(b) *Copepoda.*

Shell jointed, forming a buckler enclosing the head and thorax. Legs, 5 pairs.

		Families.			*Genera.*
A single eye.	Both superior antennæ in the male with a swollen joint .	*Cyclopidæ* .	Foot-jaws, 2 pairs.	Large and branched; ovaries 2	(1.) Cyclops.
				Small and simple; ovary 1	(2.) Canthocamptus.
	Male with a swollen hinge on right superior antenna only .	*Diaptomidæ*.	Foot-jaws, 3 pairs.	Ovary 1	(3.) Diaptomus.

Habitat.—In ponds and ditches.

2. *Branchiopoda.* (Plate XXI.)

(a) *Phyllopoda.*

Legs from 11 to 60 pairs; joints foliaceous, branchiform.

		Families.		*Genera.*
Body	Naked .	*Branchiopodidæ*	Tail simply bifid	Artemia.
			Tail in two distinct pieces .	(1.) Branchipus.
	In a shell	*Aspidephora.*	. . . .	(2.) Apus.

Habitat.—Respectively in salt-pans, ditches, and pools.

(b) *Cladocera.*

Body included in a pseudo-bivalve carapace. Legs, 5 or 6 pairs.

		Families.		*Genera.*		
A single eye.	Intestine simple, no black spot in front of the eye .	*Daphnidæ*	Legs, 6 pairs	(7.) Daphnella . .	2 & 2 jointed	Branches of the inferior antennæ.
				(8.) Sida	3 & 2 jointed	
			Legs, 5 pairs	(5.) Daphnia . . .	4 & 3 jointed	
				(6.) Bosmina . . .		
	Intestine convoluted, a black spot in front of the eye .	*Lynceidæ.*	Legs, 5 pairs	(1.) Chydorus . .	3 & 3 jointed	
				(2.) Camptocercus .		
				(3.) Alona		
				(4.) Pleuroxus . .		

Habitat.—In ponds, ditches, tanks, and reservoirs; usually in good water.

B. Malacostraca. (Plate XXII.)

a. Edriophthalmata.

(a) *Isopoda.*

(1) *Asellus aquaticus* appears to be the only fresh-water Isopod. Its distinguishing features are the following:—Superior antennæ, at least as long as the peduncle of the inferior ones. The seven pairs of legs of the Order, with the terminal hooks entire; and two bifid needle-like processes at the posterior extremity of the body.

Habitat.—Plentiful in stagnant pools, passing the winter in the mud, from whence it emerges in the spring.

(b) *Amphipoda.*

Gammarus is the only genus of *Amphipoda* occurring in fresh water. A short branch arises from the tip of the third joint of the superior antennæ, and the four anterior legs are in the form of small claws with the movable tip folding on the inner side.

(2) *Gammarus pulex* is the type of the genus, and abundant in fresh-water brooks where there is an accumulation of vegetable débris.

G. fluviatilis, another fresh-water species, is at once distinguished by the presence of a dorsal spine at the posterior border of each abdominal segment.

Note.—In concluding the notice of the Crustacea it must be mentioned that the larvæ of some of the *Oniscidæ* or wood-lice are aquatic.

2. *Arachnida.* (Plate XXII.)

(a) *Tardigrada.*

The water-bears are distinguished by having the head marked off from the thorax, while the thorax and the abdomen are confluent. The body is faintly divided into four segments, carrying each a pair of obscurely three-jointed legs, with three or four claws at their extremity. They form but one family, including three genera as under:—

			Genera.
Head.	With appendages	Mouth conical, without sucker or appendages	(1.) EMYDIUM.
		Mouth sucker-like, with palpiform appendages	(2.) MILNESIUM.
	Without appendages	Mouth sucker-like, without appendages	(3.) MACROBIOTUS.

Habitat.—Stagnant water amongst water-plants, in wet moss, and even in the gutters of houses, from whence they may be washed into cisterns and water-butts.

(b) *Acarina.*

In this Order we find the *Hydrachnea* or water-mites, with the head, thorax, and abdomen all fused together; the Palpi with the last joint unguiculate or spinous; the eyes two or four, and the legs generally ciliated and natatory, the posterior pair the longest. Of the several genera *Hydrachna* would appear to be the most commonly met with. (1) *Hydrachna globula* is subovate in form, of a rich deep red colour, with two pairs of eyes at a moderate distance apart, and the skin is covered with minute puncta. The generic name *Achlysia* has been given to the hexapod (six-legged) young of this genus, the Nymphs of which are parasitic on aquatic insects. (2) *Hydrachna geographica.* (3) A still more globular form. (4) *Limnochares holosericus,* crawling, not natatory.

Habitat.—In ponds and permanent lodgments of water. *H. globula* uses its legs with great activity, as though running through the water, instead of swimming.

3. *Insecta.* (Plate XXIII.)

The more usual aquatic larvæ are of the following Orders, as given by Kirby and Spence, and are sufficiently numerous to suggest that they would be more readily determined by the use of figures than by description, however elaborate.

Families.	*Genera.*
(*a*) *Coleoptera*	Dytiscus, Hydrophilus, Gyrinus, Limnius, Parnus, Heterocercus, Elophorus, Hydræna.
(*b*) *Hemiptera*	Gerris, Velia, Hydrometra, Notonecta, Sigara, Nepa, Ranatra, Naucoris.
(*c*) *Lepidoptera*	A few (as Nymphula).
(*d*) *Trichoptera*	The majority (Phryganea, &c.)
(*e*) *Neuroptera*	Libellula, Æshna, Agrion, Sialis, Ephemera.
(*f*) *Diptera* .	Culex and Tipulariæ.
(*g*) *Aptera* . ..	Atax and some Poduræ.

The smaller species of water beetles, *Hydrophilus, Elophorus, Hydræna, Parnus, Limnius,* and also *Nepa,* walk upon the water. The swimmers generally have the posterior legs fitted for the purpose. Thus, in *Dytiscus* and *Notonecta* they are furnished with a dense fringe of hairs on the shank and foot, and in *Gyrinus* the terminal joints are very much dilated.

Some insects walk and swim upon the surface without diving, as *Gerris lacustris,* the water-bug, which can walk, run, jump, or swim upon the surface.

Hydrometra stagnorum, very slender in form with prominent hemispherical eyes, apparently in the middle of the body, though really on the head, rambles over stagnant water, and *Velia rivulorum* courses rapidly over running streams and rivers.

V. Mollusca.

A. *Molluscoida.*

The *Limniades* or fresh-water Polyzoa are thus characterized. *Polyzoarium* fleshy, spongy, or coriaceous; apertures angular or round, closing when the zooids recede. Tentacula ciliated in a single series, fringing a more or less crescentic lophophore (*Phylactolæmata*), or an orbicular one (*Gymnolæmata*), in both cases including the mouth. The genera *Cristatella* and

Plumatella are examples of the former group, while *Paludicella* and *Urnatella* represent the latter.

The *Polyzoarium* in the *Cristatellidæ* is membranous, sacciform and free, or floating, while that of the *Plumatellidæ* is fixed, fistular, and confervoid.

Habitat.—Ponds and lakes.

B. *Mollusca* (proper).

The simple recognition of the shell, univalve or bivalve, will suffice for the *Mollusca* proper, or the fresh-water shell-fish, so called; conchological works may be consulted if necessary. The following genera occurring either in this or other countries are merely cited as examples.

1. *Lamellibranchiata* (Bivalves).

(a) *Asiphonida*, *Anodon*, *Unio*, (b) *Siphonida*, *Cyclas*, *Pisidium*, *Cyrena*.

2. *Gasteropoda* (Univalves).

(a) *Prosobranchiata* (Operculate).

Neritina, *Navicella*, *Paludina*, *Ampullaria*, *Hydrobia*, *Valvata*, *Melania*.

(b) *Pulmonifera* (Inoperculate).

Limnæa, *Physa*, *Planorbis*, *Ancylus*.

MICROSCOPICAL EXAMINATION OF AIR.

THE study of the aquatic *Infusoria* and *Algæ* is more particularly associated with the microscopical examination of drinking-water, while the smaller *Fungi*, including also the *Bacteria* and other minute and specifically light bodies, appertain especially to the examination of air. There is, however, so much in common between the two branches of inquiry, and as the ultimate mode of observing the objects obtained is precisely the same in both cases, a short section on the microscopical examination of air may be profitably appended to the foregoing pages.

From an early period the record of the nature and character of suspended matters in the air has usually claimed attention as a supplement to its chemical analysis; but the large share supposed to be taken by the protophyta in the production of specific forms of disease, and improved means of observation have, of late years, given a great impetus to this important research in the interests of Hygiene.

Numerous schemes have been suggested from time to time for the more efficient collection of suspended matters for examination, but only a cursory glance at the more important of these can be given here. There is (1) the *Aëroscope* of Pouchet, in which the air is brought by aspiration through a small funnel and made to impinge upon a glass slide armed with glycerine. 2. The *Aëroconiscope* of Maddox* which is a larger and more complex contrivance than the last, on the same principle, but requiring no aspiratory arrangement. In connection with the use of this instrument Dr. Maddox employed his well-known cultivation test, with the view of determining the true nature of the spores obtained.

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* See *Monthly Microscopical Journal* for June 1, 1870.

3. Staff Surgeon Watson used glass threads soaked in glycerine, or even dry powdered glass, through which the air was drawn by means of an aspirator.

4. Professor de Chaumont, F.R.S., employs a bent glass tube surrounded with ice or a freezing mixture, the water of the air itself as it passes through the tube is condensed, while any solid particles present are arrested in it.

5. The last-mentioned authority, however, considers it the best plan to carry the air through a succession of bottles containing pure distilled water, and in this the author fully concurs; for while the sediment may be readily placed under the microscope, the liquid part can be used for the chemical determination of organic matter, &c.

The quantity of air submitted to experiment will be indicated either by the capacity of the chambers used for aspiration or by measuring the quantity of water drawn off; one fluid ounce being nearly equivalent to 1·728 cubic inches, so that 1000 ounces would represent 1 cubic foot. (Parkes.)

It may be necessary to examine—(1) the external air; (2) the air of apartments; or, (3) the air of the soil. The first of these objects may be answered by the Aëroconiscope of Dr. Maddox; the second by any other of the foregoing processes; in addition to which the examination of cobwebs should be mentioned as likely to afford useful results. Every spider is the unconscious preparer of interesting experiments for the hygieist, for, whatever may be the nature of the suspended matters in the air, whether of an ordinary or special character, they are sure to be entangled in the adhesive matrix of the web.

Mineral particles, products of combustion, the heterogeneous materials of dust, so called, débris of animal or vegetable origin; the down of feathers, epithelium, hair, wool, and silk; linen, cotton, and woody fibre; starch granules, mycelia and spores of fungi might be called the staple objects. The two latter, however, should be especially sought for and determined, if possible, with any forms of bacteria that may be present, either free or in their gelatinous frond.

In all workshops where trades and manufactures are carried on, the prevalent suspended matters are sure to be found in the cobwebs, though of course a quantitative determination would be quite out of the question. It is curious to remark that in bed-rooms, linen and cotton fibres are more generally diffused than the wool from the blankets, the latter being usually covered with a quilt.

Lastly, for the collection of materials from the soil air, tubes must be sunk to the required depth, and the air drawn up in the usual way by aspiration.

Some excellent samples of soil air products were thus obtained at Netley several years ago, the tubes having been inserted near the outer opening of the main sewer of the Royal Victoria Hospital. A considerable amount of epithelium and other organic débris, both animal and vegetable, with fronds of bacteria were observed on that occasion, and great promise was afforded of the results of further investigation in this new field of research. Some light also appeared to be thrown upon the occasional appearance of specific diseases, without any obvious clue to their mode of origin. We are now aware that the epithelia cast off in the ordinary exanthems may be regarded as so many little cartridges charged with contagia, and that they may remain dry or moist for a lengthened period and still retain their integrity as anatomical elements.

In reference to the Microscopic Fungi constituting the *smuts, mildews,* and *moulds* the following particulars may be useful. These belong respectively to the *Conomycetes Hyphomycetes* and *Physomycetes,* so called. They all agree in having a more or less tufted and interlaced filamentous *Mycelium* (the plant proper), and a fructifying part bearing the spores, which latter are either simple or septate. In the two first orders the spores are naked, either grouped together (*Conomycetes*), or solitary (*Hyphomycetes*), while in the remaining order (*Physomycetes*) they are enclosed in little sacs. Even where the thallus or mycelium is aquatic, the fructifying part shoots up into the air, at once distinguishing the fungus from any algal it might otherwise resemble.

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